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For the
British Orthopædic Association

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The Journal *of* Orthopædic Surgery

SPECIALISM AND GENERAL SURGERY. BRITISH ORTHOPÆDIC ASSOCIATION. PRESIDENTIAL ADDRESS.

BY E. MUIRHEAD LITTLE, F.R.C.S.,

Senior Surgeon to the Royal National Orthopædic Hospital, London.

THE occasion of the first annual meeting of the British Orthopaedic Association seems to be a fitting one for the review of some of the aspects of the past history of orthopaedic surgery in this country, and for some aspirations for its future.

When subcutaneous surgery was given to the surgical world in the fourth decade of the last century, at the very beginning of that Victorian age, which was so rich in achievement in every field of art and science, but which it is now the fashion to affect to despise, orthopaedic surgery may be said to have awakened from the post-natal torpor in which Andry left it, so that it attracted the attention of surgeons everywhere. But after a generation had passed and orthopaedics had become almost synonymous with tenotomy and the use of instruments, or at least with subcutaneous—to the exclusion of open—methods, the subject lost interest for many surgeons, and orthopaedic hospitals were not thought much of.

So far had this tendency gone that, in 1872, a long and pompous editorial in an influential medical journal declared the existence of the hospitals to be an evil and stated that "there is probably *no* general hospital in England in which cases of deformity would not be received and cured, *no* hospital surgeon who would not treat them well..... as part of the ordinary work of his daily calling" (the italics are mine).

The journal returned to the subject week after week and in a later issue referring to an orthopaedic hospital, of which the domestic affairs were unpleasantly prominent, we may read:—"Cut it down, why cumbereth it the ground? There is not, as we have said already, the shadow of a pretence for saying that it is required to meet a public want." Lest the editor's remarks should be thought to apply only

to one institution, a week later he was careful to add:—"We fear Cæsar and Pompey are very much alike and that the other orthopædic hospitals differ from their elder sister chiefly in the fact stated—that they are not Royal."

Orthopaedic specialists were not alone in incurring the censure or contempt of the orthodox press, for all special hospitals found themselves in the chilling shade cast by journalistic disfavor. Yet it was at a special hospital that Spencer Wells made ovariotomy a success, and nearly all progress in the surgery of the eye, ear and throat may be traced to specialists and special institutions.

It would be unfair to attach too great importance to the opinion of one writer, but the fact remains that, as usual, the anonymous editor did represent a considerable body of professional prejudice, for other expressions of opinion adverse to specialism could be quoted.

In 1881 when the International Medical Congress was about to meet in London, an orthopaedic surgeon of European reputation approached his friend, Sir James Paget, the President, with a request for the inclusion in the congress of a section of orthopaedic surgery. This request was not granted, on the plea that there were not, in England, enough orthopaedic surgeons of good repute to officer the section! It was not until the meeting of the congress in 1890 at Berlin, largely at the instance of our American brethren, who had in the meantime founded the vigorous American Orthopedic Association, that an orthopaedic section was admitted.

It is hardly necessary for us as orthopaedic surgeons to ask ourselves whether the medical journalist of 1872 was justified, or whether all general surgeons might have been trusted to treat deformities successfully. We know that often they failed lamentably and disastrously for the patient. Failed not from lack of intelligence or of operative skill. but lack of attention to details and want of that necessary experience which cannot fall to the lot of the majority of general surgeons. In want of this experience they were often driven to rely, as their predecessors of the eighteenth century had relied, upon mechanicians, to whom they relegated much of the most important part of treatment. I have seen a prescription written a good many years ago by a then rising surgeon on the staff of a children's hospital for a case of paralytic deformity of the leg and foot, which ran as follows: "Suitable boot and instrument." Things have not changed much since those days for, only this year one of our medical journals contained an article by the same distinguished surgeon, now of world-wide fame, solemnly describing how with the help of an instrument maker he had devised a certain appli-

ance for a case of deformity. Just such appliances have been used for years by orthopaedic surgeons for just such cases. But he, dwelling on the Olympian heights of pure but general surgery cared for none of these things.

Why was it that our specialty had thus fallen into disrepute? It was unjustly condemned, but yet I think that there was some foundation for the accusations against it, some fire behind the smoke of calumny. Orthopaedic surgery had tended to be too conservative and to adopt as its motto *"Stare super vias antiquas."* Listerism, which had robbed the open wound of many of its terrors, was in 1872 slowly breaking down the walls of prejudice behind which the older metropolitan surgeons were entrenched, and the advantages of skill in subcutaneous surgery were less apparent than had been the case during the previous thirty years. Yet some of the older orthopaedic surgeons refused to use the weapon which one of the greatest Englishmen of his time offered to their hands. Even across the Atlantic some of the more conservative of the founders of the American Orthopedic Association protested against the radical procedures adopted by the younger men, but happily they protested in vain.

During my later years of student life I was told that orthopaedic surgery was dead, and writers such as the editor of the journal from which I have quoted had assured us a few years earlier that all specialism was dying. I can only say with King Charles the Second, that it has been "an unconscionable time a'dying;" and now nearly half a century later, it seems very much more alive than ever.

Gentlemen, I venture to express the opinion that it is not specialism, and not the specialist that is *in articulo mortis*, but the general surgeon, the all round man with no special line of his own. The scope of surgery has become so wide, its technique has become so elaborate that only a man with the powers of a Whewell could hope to be proficient all round.

The war is an awful calamity, but it has some compensatory advantages, among which may be counted the recognition of the need of trained orthopaedic surgeons for the treatment of many injuries. We owe this recognition partly to the good work done early in the course of the war by our New England friends and still more as regards this country to our Inspector of Military Orthopaedics, Major-General Sir Robert Jones. What would our editor of 1872 have said had he been told that in 1918 there would be 30,000 beds in Military Orthopaedic Hospitals under the direction of a specialist appointed by the Government?

The ground thus gained for orthopædics in wartime will not, I trust, be lost in peace time. In the interest of the public it is desirable that

many injuries which formerly were treated by the general surgeon should henceforth be treated by the specialist, as they now are treated in Military Orthopaedic Hospitals.

It is still more important that the treatment of these injuries should be taught by orthopaedic surgeons on the staff of all our medical schools and that more attention should be devoted to such common injuries as fractures of the long bones, the treatment of which and instruction in the treatment of which, is now thought scarcely worthy of the notice of some hospital surgeons. At least one of the great general hospitals of London, having a medical school attached to it, does not admit cases of fracture to its wards. This means that the students from that school go forth to practise their profession without having had any practical experience of the treatment of fractures of the lower extremity!

Were the treatment of fractures properly taught by specialists there would be less need for extensive bone plating operations which, although they have given brilliant results in well equipped hospitals, cannot be generally adopted throughout the country, whereas the thorough and proper use of instrumental methods is applicable by every well trained general practitioner. Were fractures, dislocations and sprains properly treated as a rule, the Bone Setters would find less excuse for their existence.

This Association owes a debt of gratitude to our American colleagues, whose cordial sympathy and advice have helped us in forming this society and who have so freely placed the fruits of their experience at our disposal. Not only have they done this but they have generously enabled us to share with them an orthopaedic journal on terms most advantageous to us.

Our two nations are for the first time allied in a great war in the cause of Right and Freedom; our Associations, without formal bonds, are united by common interest and in the common cause of Science and Humanity.

To those of you who, despite the absorbing preoccupation of these times, have provided papers for this meeting, our thanks are due.

When in future years my successors in the chair have—as I am sure they will have—a plethora of theses and of subjects of discussion, I trust that they will not despise the day of small things in the infancy of the Association. May the vigourous infant whose cradle we rock today become a prosperous adult, spreading the benefits of knowledge and experience of orthopaedics throughout the profession and the community.

THE CHANGES PRODUCED IN THE GROWING BONE AFTER INJURY TO THE EPIPHYSEAL CARTILAGE PLATE.

BY S. L. HAAS, M.D., SAN FRANCISCO,
Captain, Medical Corps, U. S. Army.

[From the Pathological Laboratory and the Surgical Pathological Laboratory of Leland Stanford, Jr., Captain, Medical Corps, U. S. Army.

THE longitudinal growth of bone is maintained by changes constantly taking place in the epiphyseal cartilage plate. As long as this highly differentiated cartilage mass persists there is opportunity for further increase in length, but with its ossification there is loss of that property. As a working principle it is necessary to know the exact portion of the epiphyseal cartilage plate that is most essential to bone growth. In the previous article[1] on the subject the following facts were ascertained. The greatest growth activity is localized in the cartilage columns of the epiphyseal cartilage plate and after the destruction of this portion of the plate length growth practically terminates. The metaphyseal cartilage serves chiefly as a medium for or is the site where the newly formed cartilage is transformed into osseous tissue. For the proper functioning of the epiphyseal cartilage plate it is essential that it shall receive an adequate blood supply. It has been shown previously[2] that, if all the blood vessels entering the bone in the region of the plate are destroyed, a very marked loss of growth takes place. This loss of growth is much greater than when the nutrient artery is destroyed. Therefore if through injury or disease the vascular supply is disturbed, then a resulting loss of growth will take place. Closely associated with the blood vessels is the character of the constituents of the blood. If there is lacking some necessary chemical elements a loss of growth is likely to take place. Thus in certain diseases and in abnormalities of the endocrine system disturbances in growth frequently occur.

Trauma is the most frequent cause of disturbances in growth of bones. The effects of trauma are quite variable and seemingly inconstant. It must be remembered that an injury in the region of the epiphyseal cartilage plate may be confined entirely to the superficial tissues, to the deeper tissues containing the vascular supply to the epiphyseal cartilage plate, to the epiphyseal cartilage plate itself or may be a combined injury of more than one of these structures. Upon the severity of the destructive process to these vital growing parts depends the resulting disturbances in growth. In the following experiments a large variety

of injuries of known degree and of known positions have been made and it is hoped that from the results obtained we will be better able to anticipate what will be the clinical picture and prognosis after certain injuries.

LITERATURE ON INJURY TO EPIPHYSEAL CARTILAGE PLATE.

The literature on injury to the epiphyseal cartilage plate from the clinical side is very extensive, but from an experimental standpoint is rather limited. At this time references will be confined to the latter and particularly to those articles which have a bearing upon the subject matter of this paper.

As early as 1872 Bidder[3] performed a series of experiments upon rabbits in which he stuck needles into the region of the epiphyseal plate and also placed cotton balls between the diaphysis and the epiphysis. He found that if he injured the outer side of the epiphyseal cartilage plate, the outer side of the bone remained shorter than the inner side; while if the inner side of the epiphyseal plate was injured then the reverse condition took place. If the whole cartilage was injured then there was an even hindrance of length growth. The epiphyseal cartilage plate was found to be degenerated or entirely missing because it was substituted through a proliferation of cells or connective tissue, or through bone trabeculae, which directly connect the diaphysis and the epiphysis.

Von Helferich[4] (quoted by Jahn) extirpated the epiphyseal cartilage plate of the distal end of the ulna in rabbits from eight days to five weeks of age and got a shortening and bending. If the cartilage was totally removed there was a complete cessation of growth.

Ollier[5] (quoted by Jahn) makes the following statements:

1. Insignificant incisions into the epiphyseal cartilage plate are without influence upon length growth.
2. Marked lesions or excisions have a strong influence and cause shortening or collapse.
3. Separation of the epiphysis is without influence if it is immediately replaced in good position.
4. The full excision of the epiphyseal cartilage causes a complete cessation of growth.

Haab[6] (quoted from Jahn). Sticking pegs into the diaphysis causes stimulation of growth because of the indirect stimulation of the epiphysis. When the epiphysis is directly stimulated or so treated there is a resulting shortening.

Vogt,[7] 1877, from a series of experiments on goats and lambs in conjunction with Telke and Thiel found that the removal of the cartilage between the diaphysis and epiphysis caused a growth disturbance in the operated bone ends, that separation of the cartilage from the diaphysis with simultaneous injury to the cartilage caused length growth disturbances; while injury to the adjoining diaphyseal end caused disturbance only when there was a destruction of a large part of the diaphyseal end. In one set of experiments he inserted a layer of gold leaf at the place of separation of the diaphysis and epiphysis and got a considerable amount of disturbance. He ascribed the loss of growth in this case to be due to the hindrance of the penetration of blood vessels from diaphysis into the epiphysis.

De Paoli,[8] 1882, experimented with two to four months old rabbits in which he loosened the lower epiphysis of the tibia. He found that healing took place through an outer callus and that as long as the periosteum remained intact and connected diaphysis and epiphysis no pseudo-arthrosis took place. Microscopically he found that the outer callus is of periosteal origin. He also found the epiphyseal cartilage bounded by the diaphysis dies while the rest remains alive and proliferates.

Ghillini,[9] in 1891, made a number of experiments upon the upper epiphyseal cartilage plate of the tibia of rabbits. He inserted ivory pegs into the epiphyseal cartilage plate for a distance of one-half cm., either on the inner or outer side. He found after two months 4 mm. of shortening; after three months, 5mm.; after five months, 6.5 mm.; and after eight months, 8 mm. of shortening. One noticed a sinking in of the cartilage on the side of the peg, and displacement of the entire epiphysis. In opposition to the findings of Ollier and Trendelenburg, he found that the ivory peg disappeared. This difference he ascribes to the fact that his peg was placed in the epiphyseal cartilage while the others placed theirs in the bone substance. Microscopically he found that after 18 days the epiphyseal cartilage plate had changed and that the cartilage columns were smaller, shorter, and more irregular; while at two months some parts had disappeared, and at eight months were entirely absent; while the normal were still present.

Jahn,[10] 1892, says that simple incisions at the junction of the epiphysis and diaphysis in bones of young rabbits is without effect upon the bone growth.

Nové-Josserand,[11] in 1893, produced longitudinal cuts and stabs into the epiphyseal cartilage of growing rabbits. Histologically he found

that the cartilage reacted with a fibrillar splitting of the ground substance and atrophy of the cartilage cells. These injuries remained in a restricted place but they could spread out. In the injured place diaphyseal ossification ceases and for this reason there is the great hindrance of length growth. In the injury which simultaneously affects both epiphysis and cartilage he found new bone tissue penetrating the cartilage from the epiphysis at the place of injury and finally inserting itself into the ossification line. Through this new bone tissue, which is wedge-shaped and which penetrates the entire epiphyseal cartilage, a synostosis between epiphysis and diaphysis is formed, and acts as a strong resisting nail to hold both together, and through this length growth is strongly influenced or stopped. He states that if this nail forms quickly then growth disturbances will be considerable, while if it is formed slowly there will be little effect upon growth.

Zoppi,[12] in 1901, made a series of experiments upon rabbits from one to three months of age. He made incisions into the upper end of the tibia in the neighborhood of the knee joint. Under microscopic examination he found that these incisions passed through the epiphyseal cartilage plate in the part where the capsules of the cartilage cells were enlarged and the cells of the same showed a plain growth proliferation. They were therefore within reach of the so-called proliferating cartilage zone. In order better to study the circulatory changes he injected Berlin Blue into the aorta. He found that on the second day after operation a fibrinous exudate, some destruction of the cartilage cells on the diaphyseal side of separation (these he claims have a lessened life property), and slight changes in the periosteum. On the fourth day there was evidence of destruction of blood corpuscles, cartilage cells, and a slight proliferation in the osteoblastic layer of the periosteum to form a thin callus. At 5-6 days there was more advanced ossification of the proliferation zone and penetration of finger-like masses of cartilage from the epiphysis. On the eighth day the line of calcification became more regular and the cartilage projections decreased in size. On the 10-11 days it was almost impossible to distinguish it from the normal. Zoppi always compared the operated bone with the normal and he never found any hindrance in the growth. Zoppi concludes that after such incision healing takes place under the influence of newly formed bone and that there is no resulting disturbances even in width of the epiphyseal cartilage line or in length of the bone.

Riedinger,[13] in 1904 (reported in 1909), cut through the lower epiphysis of the ulna in 6-8 weeks old rabbits. He found that most of his cuts went through the calcification zone of the diaphysis. Some injury of the epiphyseal cartilage was produced by rubbing of the diaphysis upon the epiphysis. This injury is dangerous if ossification is greater than the new cartilage. He found the following from his preparations of 3, 6, 9, 12, 22, 28, and 80 days. Through a proliferation of cartilage, marrow and periosteal callus the effect was gradually closed and finished at 28 days. In the epiphysis there are also certain changes, as a solution of the bone and the formation of a new epiphyseal cartilage plate. In eight cases after 40 days there was a marked atrophy of the cartilage and a bone bridge between diaphysis and epiphysis took place. It is to be taken for granted that here there was an injury to the cartilage with partial destruction. Reiner took exception to Riedinger's conclusion and said that his changes were due to infection. In conclusion Riedinger says that it is not easy to make a prognosis in man in traumatic epiphyseal separation as based upon his findings, because in man length growth proceeds more slowly and the time of cessation of length growth in the process of healing is comparatively short.

Nakahara,[14] 1909, presented a paper upon the healing processes that take place following an incision through the epiphyseal cartilage plate of rabbits. He utilizes the operative material of Riedinger, a description of which was given in the last review. He cut the lower epiphysis of the ulna with a very sharp chisel transversely in 12 rabbits. He gives a detailed report of the Roentgen ray findings and of his microscopical study in a series of experiments with duration of 3, 6, 9, 12, 17, 22, 28, 40, 80, 210, and 360 days. He found that most of the incisions passed through the ossification zone. It is an important point to know the exact position of the cut, as variation in position will give variation in results. Nakahara in general found a shortening and states that his results differ from those of Zoppi because Zoppi's incision passed directly through the cartilage. He also says that Zoppi did not make any observations after 30 days, at which time there might be a shortening, still it was more apparent at a later period. Microscopically he found very early proliferation on the part of the periosteum, perichondrium, and the marrow. Also there were changes in the epiphyseal cartilage plate at first of a degenerative but later of a regenerative nature. The chief destruction was naturally found

along the path of the incision, as was the regeneration at a later period.

Meisenbach,[15] in 1910, reported the results of attempts to influence bone growth by mechanical and chemical means. By means of hypodermic needles he injected various substances into the region of the metaphysis of rabbits six weeks old. The substances injected were water, graphite pegs (through a cannula), pure iodine, pure carbolic acid, 95% alcohol, pure formalin, and 2% formalin. He reports that there were no changes following the injection of sterile water, sterile graphite pegs staphylococcus vaccine, tincture of iodine and alcohol. There were some changes after the use of sterile graphite pegs plus staphylococcus vaccine and after pure carbolic acid. In all the cases where pure formalin was injected he found the tibia enlarged at the diaphysis but somewhat shortened in total length. This shortening he cannot account for; at first microscopically he thought it was due to the destruction of the epiphyseal line but microscopically he found that the line was thickened. With a 2% formalin he found similar charges although they were not so extensive. He concludes that of all the substances used that formalin has produced the best results, on account of its antiseptic properties and its affinity for protoplasm. That it acts as an insoluble compound and therefore affects the epiphyseal line both mechanically and chemically with a distinct local rather than a systemic tendency. It causes the formation of osteogenetic tissue by influencing the zones of provisional calcification and calcified matrix and by increasing the number of osteoblasts derived from the periosteum.

I cannot agree with his conclusions and from a study of his paper I am inclined to believe that when the needle and the chemical substances reached the epiphyseal cartilage plate there was a destruction of the cartilage with early ossification of the epiphyseal cartilage plate; that the osteogenetic reaction was the natural restorative process following the destruction. If the material did not reach the plate or the amount was small then there was a slight destruction. The shortening of the bones was undoubtedly due to the destruction of a portion of the epiphyseal cartilage plate either by mechanical or chemical means. These experiments suggest rather an interesting field for further experimentation but it appears that in order to stimulate this highly developed and sensitive region one would have to rely upon chemical substances that excite cell growth rather than upon those that destroy it; and that these must be supplied through the blood stream

in order to cause no mechanical injury to the cartilage or the blood supply.

It is noticed that in the above reviews there is a lack of complete agreement of the various authors. Particularly so is this the case with Jahn and Zoppi, who state that they find no disturbance in longitudinal growth after injury to the epiphyseal cartilage plate, which is in exact contradiction to the results of the other authors who uniformly found some hindrance in growth. It was with the idea of obtaining data to help solve some of the disputed points of this important subject and obtain information that may be of clinical value and application that the following work was undertaken.

GENERAL OPERATIVE PROCEDURE.

All the experiments were performed upon young dogs or cats from six to eight weeks of age. The animals were given a general anesthetic and the operations carried out with the usual aseptic technique. The metacarpal or metatarsal bones were selected and reached through an incision on the dorsal surface of the foot. Care was exercised to preserve the tendons, nerves, and vascular supply to the part. Upon completion of the operation the wound was closed in layers, after which an adhesive plaster dressing was applied to the foot and the animal permitted to be about upon recovery from the anesthetic. The experiments have been arranged in the following grouping, in which order they will be described:

GROUP I. SIMPLE CROSS INCISION.

1. Through the epiphysis.
2. Through the epiphyseal cartilage plate.
   a. Direct incision through the plate.
   b. Separation in the line of cleavage.
3. Through the metaphyseal region.

GROUP II. LONGITUDINAL INCISION.

1. Longitudinal incision through the epiphyseal end of the bone.
2. Longitudinal incision through the entire length of the bone.

GROUP III. CROSS INCISION WITH ELEVATION OF THE DISTAL SEGMENT.

1. Through the epiphysis.
2. Through the epiphyseal cartilage.
3. Through the metaphysis.

GROUP IV. LONGITUDINAL INCISION WITH REMOVAL OF A LATERAL HALF.

1. Incision through the epiphyseal end to the line of cleavage with removal of one-half.

2. Longitudinal incision extending through the epiphysis with removal of one-half.
3. Longitudinal incision through the entire length of the bone with removal of one-half.

GROUP V. CROSS INCISION WITH REMOVAL OF THE ENTIRE DISTAL SEGMENT.

1. Incision through the epiphysis.
2. Incision in the epiphyseal cartilage plate, at line of cleavage.
3. Incision through the diaphysis.

GROUP VI. CROSS INCISION WITH REMOVAL OF THE PROXIMAL SEGMENT.

1. Incision through the epiphyseal cartilage plate at the line of cleavage.
2. Incision through the metaphysis or diaphysis.

GROUP I. SIMPLE CROSS INCISIONS.

1. Incision Through the Epiphysis.

Method. After exposing one of the metacarpal or metatarsal bones an incision is made through the epiphysis distal to the epiphyseal cartilage plate. The incision is then closed in the usual way.

Exp. 1. 24 Days. Dog 68-59.

Operation. Cut across the metatarsal III. of the right hind foot just distal to the epiphyseal cartilage plate without raising either segment. The animal died at the end of 24 days.

Gross Findings. There is no evidence of any abnormality on external examination. On longitudinal section the line of incision is still visible. The measurements are as follows: Metatarsal III, left, 2.55 cm.; difference, 0.05 cm.; right, 2.5 cm. Thus there is no disturbance in growth.

Exp. 2. 55 Days. Dog 87-63.

Operation. Cut across just distal to the epiphyseal cartilage plate of metatarsal IV. of the right hind foot. The animal died at the end of 55 days.

Gross Findings. There is good healing with no evident changes in the operated bone. The measurements are as follows: Metatarsal IV: left, 3.75 cm.; difference, 0.1 cm.; right, 3.65 cm. Thus there is no disturbance in growth.

Exp. 3. 79 Days. Dog 13-51.

Operation. Cut through distal to the epiphyseal cartilage plate of the metatarsal III. of the left hind foot. The animal was killed by illuminating gas at the end of 79 days.

Gross Findings. The operated bone appears thickened at the distal end, otherwise it is normal. On longitudinal section the distal fragment separated, as it was not firmly united. There is no difference between the operated and the normal bone except at the line of incision. There is very little callus present and it appears as though cartilage is growing in from the articular cartilage. The measurements are: Metatarsal IV., 5.25 cm.; metatarsal III., 5.05 cm. This gives a loss of 0.2 cm. in the operated bone.

The Roentgenogram shows the line of incision through the epiphysis with some distortion and shortening of the epiphysis itself. There is definite shortening of the operated bone.

Microscopical Findings. There is a definite line of separation in the epiphysis. The articular cartilage is normal. At the line of separation in the epiphysis there is some tendency for an ingrowing of the articular cartilage and of the cartilage of the epiphyseal cartilage plate beneath the periosteum. Along the line of separation there are areas of cartilage which appear to have their origin from the connective tissue while other pieces of cartilage appear to be forming about the trabeculae. The epiphyseal cartilage plate is of fairly normal appearance. The remainder of the bone is normal.

SUMMARY ON INCISION ACROSS THE EPIPHYSIS.

There is only a very slight, if any, disturbance in growth following such an operation on a growing bone.

TABLE I.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
1	68-59	24 days	0.05 cm.	0.2 cm.	0.25 cm.
2	87-63	55 "	0.1 cm.	1.2 cm.*	1.3 cm.*
3	13-51	79 "	0.2 cm.	2.05 cm.*	2.25 cm.*

* Estimated.

2. INCISION THROUGH THE EPIPHYSEAL CARTILAGE PLATE.

a. DIRECT INCISION.

Method. The selected bone is exposed and the epiphyseal cartilage plate made visible. Then an incision is made directly through the cartilage without separating the surrounding tissues. The fragments are held in apposition by sutures through the overlying tissues and the wound is closed in layers.

EXPERIMENT 4. 62 DAYS. DOG 122-76.

Operation. Cut through the epiphyseal cartilage plate of the metacarpal IV of the left fore foot. The bone measured 2.9 cm. The animal died at the end of 62 days.

Gross Findings. There is good healing. There is an irregularity in the shape of the diaphysis due to a bulging out 0.5 cm. from the epiphyseal cartilage plate. Otherwise the appearance is normal. On longitudinal section the epiphyseal cartilage plate shows a defect in its center. The marrow appears normal.

The measurements are: Metacarpal IV, left, 3.5cm.; difference, 0.55 cm.; right, 4.05 cm.

Thus there is a lost of 0.55 cm. The growth of the op. bone is .6 while that of the normal is 1.15 cm.

Microscopical Findings. The epiphyseal cartilage plate is narrower than normal and at its central part there is an entire absence of cartilage, allowing a communication between the marrow cavity of the diaphysis and epiphysis. There is nothing special to be noted in the enlargement of the diaphysis, the change in shape is most likely due to disturbances following the incision. It is possible that after the incision new bone is deposited and the epiphyseal cartilage plate advanced farther on.

EXPERIMENT 5. 65 DAYS. DOG 106-70.

Operation. Made an incision through the epiphyseal cartilage plate of metacarpal IV of the left fore foot. The bone measured 2.85 cm. The animal died 65 days after the operation.

Microscopical Findings. The joint cartilage appears normal. There are no external abnormalities except that the epiphysis is distorted posteriorly on the shaft. On the longitudinal section there is found to be some distortion of the epiphyseal cartilage plate. The measurements are: Metacarpal IV, left, 3.2 cm.; difference 0.5 cm. Metacarpal III. 3.7 cm.

There is a loss of growth of 0.5 cm. The growth of the operated bone is 0.35 cm., while the normal growth is 0.85.

The Roentgenogram shows the shortening of the operated bone as well as the distortion of the epiphysis. (See Fig 1.)

Microscopical Findings. The articular cartilage appears normal. The marrow and trabeculae appear normal.

There is no evidence of the line of incision. The epiphyseal carti-

FIG. 1.—Experiment 5. Sixty-five days. Dog 106-70. Incision through the epiphyseal cartilage plate. Right in photograph, B, second bone from the right, 4, is the operated bone, showing the shortening when compared with its neighbor, 3, which it normally equals. Left in Photograph, A, shows the normal relation of the length of the bones (3 and 4 are equal in length).

lage plate is fairly regular but considerably narrower than the normal. There is a lack of cartilaginous buds projecting from the metaphysis into the diaphysis.

EXPERIMENT 6. 79 DAYS. DOG 14-50.

Operation. Cut through the epiphyseal cartilage plate of the metacarpal III of the right fore foot without severing from the surrounding tissue. The bone measures 2.7 cm. The animal was killed with illuminating gas at the end of 79 days.

Gross Findings. The bone is shorter and the epiphyseal end is distorted. On longitudinal section the epiphyseal cartilage plate is found to be distorted. The part beneath the dorsal surface is absent and replaced by new bone. The remainder of the plate is not so prominent as the normal. The measurements are: Metacarpal III, left, 5.05 cm.; difference, 1.25 cm.; right, 3.8 cm.

Thus there is a loss of 1.25 cm. The growth of the operated bone is 1.1 cm. while the normal growth is 2.35 cm.

Microscopical Findings. The general structure of the bone is normal. The epiphyseal cartilage plate is almost absent dorsally and is replaced in part by young osteoid tissue. The remainder of the line is not so regular and even as normal. The columns of cartilage are

short and uneven. There is not the long regular projection of ossifying cartilage buds in the metaphyseal region.

The marked loss of growth in this experiment is not wholly due to the incision. It was more than likely that with the displacement of the fragment additional injury was caused with a consequent loss of growth.

SUMMARY ON INCISION THROUGH THE EPIPHYSEAL CARTILAGE PLATE.

In each instance there is a definite disturbance in growth. Following such an incision there is a restoration of the continuity and form of the epiphyseal cartilage plate, although there is a lessening of its width. Growth does not cease but it appears that the ossification of the plate is hastened as indicated by changes in its center. The greater the injury to the epiphyseal cartilage plate the greater the disturbance in growth.

TABLE II.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
4	122-76	62 days	0.55 cm.	0.6 cm.	1.15 cm.
5	106-70	65 "	0.5 cm.	0.35 cm.	0.85 cm.
6	14.50	79 "	1.25 cm.	1.1 cm.	2.35 cm.

b. INCISION THROUGH THE PERIOSTEUM WITH SEPARATION IN THE LINE OF CLEAVAGE.

Method. An incision is made through the periosteum around the dorsal and lateral aspects of the bone, after which pressure is made upon the head of the bone. The epiphysis separates from the metaphysis uniformly in the region of the large vesicular cells of the column of the cartilage.

EXPERIMENT 7. 62 DAYS. DOG 122-76.

Operation. After exposing the epiphyseal plate of the metacarpal IV of the left fore foot an incision is made through the periosteum and separation made in the line of cleavage. The bone measured 2.9 cm. in length. The animal died at the end of 62 days.

Gross Findings. On longitudinal section the diaphysis is found to be broad and irregular near the metaphysis. There is a defect in the center of the epiphyseal cartilage plate but the remainder of the bone is normal. The measurements are as follows: Metacarpal IV, left, 3.5 cm.; difference, 0.55 cm.; right, 4.05 cm.

Thus there is a 0.55 cm. loss of growth since the operation. The normal growth is 4.05—2.9=1.15 cm.

Experiment 8. 65 Days. Dog 106-70.

Operation. The operation is the same as in the previous experiment. The metacarpal IV of the left fore foot is the selected bone and measures 2.85 cm. in length. The animal died at the end of 65 days.

Gross Findings. The bone appears normal throughout. The measurements are as follows: Metacarpal IV, left 3.70 cm. Metacarpal III, 3.20 cm. Difference is 0.5 cm.

Thus there is a loss of 0.5 cm. since the operation while the normal growth is 3.7—2.85=0 85 cm.

Experiment 9. 107 Days. Dog 24-55.

Operation. Exposed metatarsal III of the right hind foot. After making an incision through the periosteum around the epiphyseal cartilage plate a separation is made in the line of cleavage. The parts are restored without disturbing from their normal surroundings. The animal was killed by illuminating gas at the end of 107 days.

Gross Findings. There is normal healing. There is a normal appearance throughout except for a slight change in the curve of the epiphyseal cartilage plate. The measurements are as follows: Metacarpal IV, 5.5 cm. Metacarpal III, 4.85 cm. Difference, 0.65 cm.

Thus there is a loss of 0.65 cm.

Microscopical Findings. The epiphyseal cartilage plate possesses practically a normal structure aside from a hyaline-like groundwork between the cartilage columns nearer the center. A considerable portion of the vesicular layer is absent.

Table III.

Exp. No.	Dog No.	Duration	Loss of Growth	Growth of Operated	Growth of Normal
7	12-76	62 days	0.5 cm.	0.75 cm.	1.25 cm.
8	106-70	65 "	0.1 cm.	0.75 cm.	0.85 cm.
9	24-55	107 "	0.65 cm.	1.85 cm.	2.5 cm.

Summary on Separation in the Line of Cleavage.

Thus it is noted after such an experiment there is also a disturbance in growth perhaps as much as takes place after the incision. In one experiment, No. 8, it is noticed that there is only 0.1 cm. loss of growth, so that it is possible under ideal conditions to make a separation without causing a loss of growth. In order to attain such a result a minimal amount of destruction to the cartilage cells and the circulation must be inflicted.

It is also noticed that there is about the same amount of disturbance following an incision through cartilage as there is after a separation in the line of cleavage.

3. INCISION THROUGH THE METAPHYSEAL REGION.

Method. After the exposure of one of the bones of the foot an incision is made across the bone in the region of the metaphysis.

EXPERIMENT 10. 30 DAYS. DOG 112-72.

Operation. Cut through the metaphyseal region of the metatarsal III of the left hind foot without raising either segment. The alignment is restored and the bone held by suture in the surrounding tissue. The animal died at the end of 13 days.

Gross Findings. There is good healing. The line of incision is not visible. The measurements are: Left, 3.2 cm.; difference, 0; right, 3.2 cm. Thus there is no disturbance in growth.

EXPERIMENT 11. 24 DAYS. DOG 67-59.

Operation. Cut across just on the proximal side of the epiphyseal cartilage plate of the metatarsal IV of the right hind foot. The bone measures 2.3 cm. The animal died at the end of 24 days.

Gross Findings. There is good healing. On longitudinal section one can see the line of incision passing through the bone. The measurements are as follows: Metatarsal III, left, 2.55 cm.; difference, 0.05 cm.; right, 2.5 cm. (op). The operated bone is 0.2 cm. longer while the normal is 0.25 cm. Thus there is practically no disturbance in growth since the operation.

EXPERIMENT 12. 33 DAYS. DOG 115-73.

Operation. Cut across the metaphysis of the metatarsal III of the left hind foot without raising from its bed. The bone measures 2.9 cm. The animal died at the end of 33 days.

Gross Findings. There is good healing. A line is noticed in the region of the incision. The measurements are as follows: Metatarsal III, left, 3.1 cm.; difference, 0.1 cm.; right, 3.2 cm. There has been 0.2 cm. of growth of the operated, while the normal bone has increased 0.3 cm. Thus there is a very minimal disturbance in growth.

EXPERIMENT 13. 42 DAYS. DOG 109-71.

Operation. Cut through the metaphyseal region of the metatarsal IV of the left hind foot without raising. The length of the bone is 3.0 cm. The animal died at the end of 42 days.

Gross Findings. The healing is good. From external observation there is no difference between the operated and the normal. On longitudinal section there is an entirely normal appearance throughout. The measurements are as follows: Metatarsal III, left, 3.65 cm.; difference, 0.05 cm.; right, 3.7 cm. Thus there is practically no loss of growth. The operated bone has increased 0.65 cm. in length, while the normal has increased 0.7 cm.

EXPERIMENT 14. 48 DAYS. DOG 118-74.

Operation. Cut through the metaphysis of the metatarsal IV of the right hind foot without raising either fragment. The length is 2.85 cm. The animal died 48 days later.

Gross Findings. There is good healing. Nothing abnormal is made out of an external examination. On longitudinal section there is found to be a slight change in the tissue in the metaphyseal region. The measurements are as follows: Metatarsal IV, left, 3.65 cm.; difference, 0.05 cm.; right, 3.6 cm. The operated bone has increased 0.75 cm., and the normal bone 0.8 cm. Thus there is practically no loss of growth since the operation.

SUMMARY OF INCISION THROUGH THE METAPHYSIS.

A simple incision across the metaphyseal region healed as a fracture in the shaft of the bone without causing any disturbance in length growth.

TABLE IV.

EXP. NO.	DOG NO.	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
10	112-72	——	——	——
11	67-59	0.05 cm.	0.2 cm.	0.25 cm.
12	115-73	0.1 cm.	0.2 cm.	0.3 cm.
13	109-71	0.05 cm.	0.65 cm.	0.7 cm.
14	118-74	0.05 cm.	0.75 cm.	0.8 cm.

COMPARISON OF INJURY BY INCISION ACROSS THE BONE.

It was noticed that an incision across the epiphysis distal to the epiphyseal cartilage plate and an incision across the metaphysis prox-

imal to the plate is without effect upon the longitudinal growth. An incision in the epiphysis is more likely to result in a disturbance, because there is a possibility of injuring the growing part of the cartilage column if it comes too near the plate.

An incision through the epiphyseal plate always caused a considerable loss of growth because it destroyed vital cells in the region responsible for longitudinal growth, namely of the cells of the cartilage columns. A separation in the line of cleavage may be produced without causing any disturbance in growth, but as a rule even after such an operation there is resulting loss of growth.

GROUP II. LONGITUDINAL INCISIONS THROUGH THE EPIPHYSEAL CARTILAGE PLATE.

1. Longitudinal Incision Through the Distal Portion of the Bone Including the Epiphyseal Cartilage Plate.

Method. After exposing one of the bones an incision is made longitudinally from the articular cartilage through the epiphyseal cartilage plate into the diaphysis. The bone was neither removed nor the surrounding tissues disturbed.

EXPERIMENT 15. 13 DAYS. DOG 111-72.

Operation. Made an incision longitudinally through the distal one-third of the metatarsal IV of the left hind foot. The animal died at the end of 13 days.

Gross Findings. There is good healing. The line of incision is still visible. The measurements are as follows: Metatarsal IV, left 3.3 cm.; difference, 0; right 3.3 cm. Thus there is no difference in length of the operated and the normal bones.

EXPERIMENT 16. 38 DAYS. DOG 93-66.

Operation. Made an incision through the distal one-third of the metacarpal III of the left fore foot. The animal died at the end of 38 days.

Gross Findings. The appearance of the operated bone is normal. Firm union has taken place in the line of incision. The measurements are as follows: Metacarpal III, left (op.) 2.9 cm.; difference, 0.2 cm.; right, 3.1 cm. Thus there is a difference of only 0.2 cm. between the two sides.

EXPERIMENT 17. 48 DAYS. DOG 117-74.

Operation. Split longitudinally the distal one-third of the metatarsal III of the right hind foot. The bone measured 2.85 cm. The animal died at the end of 48 days.

Gross Findings. Good healing is present. The articular cartilage shows a small defect posteriorly although the remainder is healed and appears normal. There is a trace of the incision in the region of the epiphyseal cartilage plate, but the union is firm. The measurements are as follows: Metatarsal III, left, 3.55 cm.; difference, 0.1 cm.; right, 3.45 (op.) There is only 0.1 cm. difference between the operated and normal one. The operated bone has increased 3.45—2.85=0.6 cm in length, while the normal increase has been 3.55—2.85=0.7 cm.

Microscopical Findings. The path of the incision can be followed through the articular cartilage and epiphyseal cartilage plate.

The perichondrium appears to be bridging the gap but one cannot determine exactly whether the fibrous cartilage arises from it or whether it is not being formed by a process of metaplasia. There is practically no tendency to bridge the gap in the epiphyseal cartilage plate except in the ossifying layer of the epiphysis where there is some newly formed cartilage. The columns most likely agglutinated and separated during preparation, but show no proliferation of cartilage.

The defect in the articular cartilage is filled up with a fibrous mass of tissue which in places appears like young cartilage cells.

EXPERIMENT 18. 67 DAYS. DOG 104-69.

Operation. Split the metatarsal IV. of the left hind foot through one-half its length at the distal end. The bone measures 2.85 cm. The animal died in 67 days.

Gross Findings. There is good healing. The line of incision is visible in the articular cartilage. In some places it is found to be bridged over with cartilage. The measurements are: Metatarsal IV, left, 4.2 cm.; difference, 0; right, 4.2 cm. Thus there is no loss of growth. The increase in length since operation is 4.2—2.85=1.35 cm.

SUMMARY ON LONGITUDINAL INCISION THROUGH THE EPIPHYSEAL CARTILAGE PLATE.

In no instance after a longitudinal incision extending through the epiphyseal cartilage and one-half of the bone has there been any hindrance of growth of the bone.

TABLE V.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
15	111-72	13 days	0	——	——
16	93-66	38 "	0.2 cm.	——	——
17	117-74	48 "	0.1 cm.	0.6 cm.	0.7 cm.
18	104-69	67 "	0	1.35 cm.	1.35 cm.

LONGITUDINAL INCISION THROUGH THE ENTIRE LENGTH OF THE BONE.

Method. An incision is made through the entire length of the bone without disturbing either segment from the surrounding tissues.

EXPERIMENT 19. 15 DAYS. DOG 71-56.

Operation. The metacarpal IV is split longitudinally in half but not disturbed from its natural bed. The bone measures 2.2 cm. The animal died at the end of 15 days.

Gross Findings. There is good healing. The two halves of the bone are firmly united. The measurements are: Metacarpal IV, left, 2.25 cm.; difference, 0; right, 2.25 cm. Thus there is no difference in length. It is also to be noted that there has been practically no increase in length since the operation.

Microscopical Findings. One sees a separation in both articular cartilages as well as in the epiphyseal cartilage plate. The splits in the articular cartilages are filled with fibrin undergoing organization. There is no evidence of proliferation of these cartilage cells bordering on the diastasis. The osseous tissue of the trabeculae is growing in slightly at one place. The operation in the epiphyseal cartilage plate is likewise filled with organizing fibrin but there is no evidence of proliferation of cartilage cells. Along the tract at places in the diaphysis are areas of osteoid and fibrous tissue.

EXPERIMENT 20. 15 DAYS. CAT 75-5.

Operation. Split the metacarpal IV of the left fore foot the entire length of the bone. The bone measures 1.55 cm. The animal died at the end of 15 days.

Gross Findings. The healing is good. The measurements are as follows: Metacarpal IV, left, 1.7 cm. (op.); difference, 0; right, 1.7 cm. Thus there is no loss of growth. The growth since operation has been but 0.15 cm.

EXPERIMENT 21. 55 DAYS. DOG 85-63.

Operation. Split the metacarpal III of the left fore foot its entire length. The bone measures 2.05 cm. The animal died at the end of 55 days.

Gross Findings. The healing is good. The measurements are as follows: Metacarpal III, left (op.), 3.15 cm.; difference, 0.25 cm.; right, 3.4 cm. There is a loss of 0.25 cm. in growth since the opera-

tion. The growth of the normal bone has been 1.35 cm., while that of the operated has been 1.1 cm.

EXPERIMENT 22. 62 DAYS. CAT 58-48.

Operation. Split the metacarpal IV of the left fore foot the entire length of the bone. The bone measures 1.9 cm. The animal died at the end of 62 days.

Gross Findings. The healing is good. There is a slight sliding of the segments with overlapping. The measurements are as follows: Metacarpal IV, left, 2.0 cm.; difference, 0.2 cm.; right, 2.2 cm. There is 0.2 cm. loss of growth. The entire growth of the operated bone is only 0.1, while the normal growth is but 0.3 cm.

EXPERIMENT 23. 109 DAYS. DOG 80-61.

Operation. The metatarsal III of the right hind foot is split longitudinally the entire length. It measures 2.7 cm. The animal was killed with chloroform at the end of 109 days.

Gross Findings. There is good healing. The articular cartilage

FIG. 2.—Experiment 23. 109 days. Dog 80-61. Splitting the bone longitudinally its entire length. The third bone from the left, 3, is the operated bone, and is shorter than its neighboring bone, 4, which it normally should equal.

has almost entirely healed over. The epiphyseal cartilage plate is almost of normal structure although it is not quite so regular as normal. The measurements are as follows: Metatarsal III, left, 5.1 cm.; difference, 0.5 cm.; right, 4.6 cm. There is a loss of 0.5 cm. in length since the operation. The operated bone has increased 1.9 cm. in length, while the normal bone has increased 2.4 cm. (See Fig. 2.)

SUMMARY ON LONGITUDINAL INCISION ON THE ENTIRE LENGTH OF THE BONE.

There is a definite disturbance in growth following such an incision. This loss cannot be ascribed to the direct injury to the epiphyseal cartilage plate, because it was shown in the last set of experiments, where the longitudinal incision passed through the plate that there was no loss of length growth. The loss here may be due to greater destruction of blood vessels. There is also more mobility of the two opposing surfaces, allowing a rubbing and destruction of cartilage cells in the epiphyseal cartilage plate.

TABLE VI.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
19	71-56	15 days	0	0.05 cm.	0.05 cm.
20	75-5	15 "	0	0.15 cm.	0.15 cm.
21	83-63	55 "	0.25 cm.	1.1 cm.	1.35 cm.
22	58-48	62 "	0.2 cm.	0.1 cm.	0.3 cm.
23	80-61	109 "	0.5 cm.	1.9 cm.	2.4 cm.

GROUP III. CROSS INCISION AND RAISING OF THE DISTAL FRAGMENT.

1. Through the Epiphysis.

Method. An incision is made across the epiphysis just distal to the epiphyseal cartilage plate. The tissues about the end of the bone including the joint capsule are severed, the segment raised and reimplanted. By suturing the surrounding tissue the segment is held in place.

EXPERIMENT 24. 9 DAYS. DOG 31-73.

Operation. Raised the epiphysis distal to the epiphyseal cartilage plate of the metatarsal IV of the right hind foot, and replaced. The entire length of the bone is 2.6 cm. The animal died at the end of 9 days.

Gross Findings. The line of union in the epiphysis is not firm. The measurements are as follows: Rt. metatarsal IV, 2.75 cm. (op.); Rt. metatarsal III, 2.7 cm. Thus there is no difference in length.

Microscopical Findings. The incision is found to pass just beyond the inner layer of the articular cartilage. The space is filled with fibrin and there is some evidence of osteoid growth about some of the trabeculae in the immediate vicinity.

EXPERIMENT 25. 22 DAYS. DOG 147-86.

Operation. Cut through just distal to the epiphyseal cartilage plate of the metatarsal IV of the right hind foot, raised and reimplanted. The bone measures 3.0 cm. The animal died at the end of 22 days.

Gross Findings. The joint capsule is thickened but does not contain an excess of synovia. The articular cartilage is smooth but wider than normal. The line of incision is not visible. The epiphyseal cartilage plate appears normal. The measurements are as follows: Metatarsal IV, left, 3.8 cm.; difference, 0.15 cm.; right, 3.65 cm. (op). Thus there is only a very slight decrease in size of the bone. The measurement of the operated bone is 3.68—3.0=0.65 cm., while the normal increase is 0.8 cm. The Roentgenogram shows the slight shortening and one can still make out the region through which the incision passes.

Microscopical Findings. The articular cartilage is thickened and appears fairly normal except that the cartilage cells show more grouping than usual. The marrow and trabeculae appear fairly normal throughout the epiphysis and one cannot distinguish the part operated upon. There is a fibrous ingrowth on both borders, showing the site of the incision. The epiphyseal cartilage plate and remainder of the bone are normal.

EXPERIMENT 26. 48 DAYS. DOG 131-79.

Operation. Removed the epiphysis distal to the epiphyseal cartilage plate of the metatarsal III of the right hind foot.

Microscopical Findings. There is good healing, but the external appearance of the bone is normal. The segment is not firmly united. On longitudinal section there is some evidence of reparative changes. The measurements are as follows: Metatarsal III, left, 3.7 cm.; difference, 0.1 cm.; right, 3.6 cm. (op.). Thus there is practically no loss of growth following this operation. The growth of the operated bone is 0.4 cm., while that of the normal bone is 0.5 cm.

EXPERIMENT 27. 55 DAYS. DOG 86-63.

Operation. Cut across the metatarsal III of the right foot just dis-

tal to the epiphyseal cartilage plate, raising and reimplanting the distal segment. The animal died at the end of 55 days.

Gross Findings. There is good healing. Nothing especially abnormal noted. The measurements are as follows: Metatarsal III, left, 3.7 cm.; difference, 0.2 cm.; right, 3.5 cm. (op.). Thus there is but 0.2 cm. loss in growth of the operated bone, which has increased about 1.0 cm. since the operation.

EXPERIMENT 28. 79 DAYS. DOG 12-51.

Operation. Cut across and raised the portion of the epiphysis distal to the epiphyseal cartilage plate of the metacarpal III of the right fore foot. The animal was killed by illuminating gas at the end of 79 days.

Gross Findings. There is good healing. The tissue about the joint capsules is thickened. The articular surface is irregular and covered with fibrous tissue. On longitudinal section the articular cartilage is uneven. The entire epiphysis is distorted and much smaller than normal. The line of incision can be partially made out. The epiphyseal cartilage plate appears normal except that it has a straighter contour than usual. The measurements are as follows: Right metacarpal IV, 4.7 cm.; right metacarpal III, 4.1 cm. There is a loss of 0.6 cm. That this loss is not due to the collapse of the epiphysis is evident from the measurement of the diaphysis of the two bones: Diaphysis of metacarpal IV, 4.0 cm.; diaphysis of metacarpal III, 3.5 cm. The Roentgenogram shows the shortening of the operated bone. There is a definite loss of growth of the diaphysis. The line of incision comes close to the epiphyseal cartilage plate and on one border might extend into it.

Microscopical Findings. There is a pannus of fibrous tissue covering the articular cartilage. The articular cartilage cells appear irregular and in places are destroyed. It appears as though some additional factor besides the simple incision is producing this condition. The line of incision can be followed across the epiphysis. It is irregular and in places comes very near the epiphyseal cartilage plate. At the line of incision there is an ingrowth of fibrous tissue and young cartilage; in fact, in places, it appears as though both edges of the wound were being lined by cartilage.

The epiphyseal cartilage plate is regular and normal at both ends but in the center there is a marked defect and the cartilage has been replaced by fibrous tissue. There was evidently an injury to the epiphyseal cartilage plate at this point and this explains the abnor-

mal loss of growth. The cancellous bone of the epiphysis is very scanty. The diaphysis appears fairly normal. This experiment emphasizes the important fact of knowing exactly where the incision passes in order to make a correct interpretation of the results.

SUMMARY ON INCISION DISTAL TO EPIPHYSEAL CARTILAGE PLATE AND RAISING DISTAL FRAGMENT.

Unless there is an accompanying injury to the epiphyseal cartilage plate there is practically no disturbance after such a procedure. The result is about the same as after a simple incision across the epiphysis.

TABLE VII.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
24	31-73	9 days	0.05 cm.	0.1 cm.	0.15 cm.
25	147-86	22 "	0.15 cm.	0.65 cm.	0.8 cm.
26	131-79	44 "	0.1 cm.	0.4 cm.	0.5 cm.
27	86-63	55 "	0.2 cm.	——	——
28	12-51	79 "	0.6 cm.	——	——

2. Through Epiphyseal Cartilage Plate and Raising of the Distal Segment.

Method. After exposing the epiphyseal cartilage plate an incision is made in the periosteum and the epiphysis is separated from the metaphysis in the line of cleavage. The entire epiphysis is then raised from its bed and reimplanted. The fragment is held in place by sutures through the overlying tissue.

EXPERIMENT 29. 9 DAYS. DOG 30-73.

Operation. Separated the epiphysis of the metatarsal III of the left hind foot and reimplanted. The bone measures 2.6 cm. The animal died at the end of 9 days.

Gross Findings. Normal healing is present. On longitudinal section the marrow of the epiphysis is of yellow color instead of the normal red. There is a whitish area at the line of union. The epiphyseal cartilage plate is swollen. The measurements are 2.85 cm. of the normal, while the operated is 2.7 cm. Thus there is a 0.15 cm. shortening even at this early period.

Microscopical Findings. The articular cartilage appears fairly normal. The marrow of the epiphysis shows early necrosis. The nuclei of the trabeculae show loss of staining, the epiphyseal cartilage plate is swollen and the nuclei, especially of the columns of the cartilage, take a poor stain and appear partially crenated. There is little evidence of healing in the line of separation which passes through

the vesicular cells of the cartilage columns. There is some fibrinous exudate. The metaphysis appears normal except for the presence of young connective tissue near the line of incision. The remainder of the bone appears normal.

EXPERIMENT 30. 28 DAYS. DOG 144-85.

Operation. Raised and reimplanted the epiphysis of metatarsal III of the right hind foot. The bone measures 2.45 cm. The animal died at the end of 28 days.

Gross Findings. There is considerable distortion about the epiphysis. The joint cavity is obliterated and there is a fibrous tissue covering the articular cartilage. On longitudinal section the epiphysis is found to be distorted upon the shaft. There is very little cancellous bone present. The epiphyseal cartilage plate is very irregular. One portion has a fairly normal appearance and occupies a portion nearer the end than the other. The other portion of the plate is represented by an irregular cartilage-like tissue. The remainder of the bone appears normal. The measurements are as follows: Metatarsal III, left, 3.3 cm.; difference, 0.4 cm.; right, 2.9 cm. The increase of the operated bone is 2.9—2.45=0.45 cm. since the time of operation, while the normal increase is 3.3—2.45=0.85 cm.

Microscopical Findings. The articular cartilage is quite irregular in shape and there is a fibrous tissue mass on the surface. The cellular arrangement of the articular cartilage is very irregular although the structure of the cells is good. The trabeculae for the greater part are cartilaginous. The marrow contains some normal cells. The epiphyseal cartilage plate consists of two parts, one half which is fairly normal, the other which is made up of an irregular mass of cartilage in various stages of active proliferation. It appears as though there was not a complete separation in this line of cleavage and the part that is normal most likely remained behind intact. The portion that was raised has undergone certain degenerative changes in the substance of which there is some proliferation of cartilage from the perichondrium. Beyond the metaphysis the bone is of normal structure.

EXPERIMENT 31. 51 DAYS. DOG 128-78.

Operation. Reimplanting the epiphysis including the epiphyseal cartilage of the metatarsal III of the right hind foot. The bone measures 3.35 cm. The animal died at the end of 51 days after the operation.

Gross Findings. There is good healing. On external examination there is found to be a small defect in the epiphyseal cartilage plate on the dorsal surface. The "plate" appears more yellow than usual. On longitudinal section there is found to be a line in the epiphysis itself, away from the "plate" as though the incision passed through that particular place. The marrow appears pale in one spot. The epiphyseal cartilage plate appears normal. The measurements are as follows: Metatarsal III, left, 4.2 cm.; difference, 0.5 cm.; right, 3.7 cm. The growth of the operated bone is 3.7—3.35=0.35 cm., while the normal growth is 4.2—3.35=0.85.

The Roentgenogram shows the shortening of the operated bone with some irregularities in the region of the epiphyseal cartilage plate and broadening of the diaphysis. It does not show the degenerative changes of the epiphyseal cartilage plate. (See Fig. 3.)

FIG. 3.—Experiment 31. Dog 128-78. Separation in the line of cleavage of the epiphyseal cartilage plate, then raising and reimplanting the epiphysis. Left in photograph, A, third bone from the left, 3, is the operated bone. Notice the shortening when compared with its fellow, 4, which it normally equals. No growth since operation. The epiphyseal cartilage plate is irregular in form.

Microscopical Findings. The articular cartilage appears fairly normal. The line that was noticed in the gross is a band of cartilage

passing across the epiphysis. The marrow of the epiphysis is for the greater part fibrous. The trabeculae for the most part show evidence of degeneration, some show regeneration on their periphery. The epiphyseal cartilage plate is fairly regular but is lacking in the character of active, proliferative appearance. The nuclei have lost a considerable part of their staining property.

The metaphysis, although having fairly normal arrangement, lacks the normal active osteogenetic changes. The cells for the greater part have light stained nuclei and there is considerable fibrous tissue between the columns. The picture is more of degeneration than regeneration. The remainder of the bone appears normal.

EXPERIMENT 32. 62 DAYS. DOG 123-76.

Operation. Cut through at the epiphyseal cartilage, raised, and reimplanted the epiphysis of the metatarsal III of the right hind foot. The bone measured 3.2 cm. The animal died at the end of 62 days.

Gross Findings. The joint capsule is thickened and the joint cavity contains a small amount of synovial fluid. The articular cartilage is smooth. On longitudinal section it is noticed that the entire epiphyseal end of the bone is enlarged. The marrow is mottled in appearance. The epiphyseal cartilage plate is of fairly normal structure. The remainder of the bone appears normal. The measurements are: Metatarsal III, left, 4.35 cm.; difference, 0.8 cm.; right, 3.55 cm. There is a loss of 0.8 since the operation. The operated bone has increased 0.35 cm. while the normal has increased 1.15 cm.

Microscopical Findings. The articular cartilage appears normal. The marrow of the epiphysis is for the greater part normal with a scattered area of fibrous tissue and in parts an increase in vascularity. The trabeculae have a fairly normal structure. The epiphyseal cartilage plate is degenerated near the center and in part replaced by a fibro-cartilaginous tissue. At the periphery the cartilage has a fairly normal structure. The metaphysis shows a considerable change in the middle where there is a loss of the ossifying buds, they being replaced by dense bone. There is also a marked elongation of some of the columns at the center, possibly due to a superimposition of the epiphyseal cartilage plate upon some of the columns that remained in process of separation.

EXPERIMENT 33. 79 DAYS. DOG 15-50.

Operation. Raised and reimplanted the epiphysis of the metatarsal

IV of the left hind foot. The animal was killed with illuminating gas at the end of 79 days.

Gross Findings. The joint capsule is thickened and the articular cartilage is rough and irregular. On longitudinal section the articular cartilage appears slightly irregular. The epiphysis is paler than normal and there is a small soft yellowish white area near its center. The epiphyseal cartilage plate is irregular and has lost its normal glistening appearance. On one side there is a considerable amount of tissue that looks like callous tissue. The osseous tissue near the epiphyseal plate appears more dense than usual. The measurements are: Metatarsal IV, left, 4.05 cm.; difference, 1.4 cm.; right, 5.45 cm. Thus there is a loss of 1.4 cm. in the operated bone.

Microscopical Findings. The articular cartilage is covered in places with connective tissue. The cartilage in the immediate vicinity shows evidence of degeneration. The marrow elements appear fairly normal. The trabeculae are bordered by a layer of osteoblast but the nuclei of the osseous tissue are not so prominent as usual. One half of the epiphyseal cartilage plate shows marked evidence of degeneration, being for the greater part replaced by fibrous tissue. The remainder, although somewhat irregular, is of fairly normal structure. In the diaphysis there is considerable replacement of the marrow by fibrous tissue.

SUMMARY ON REMOVAL OF THE EPIPHYSIS AND REIMPLANTING.

It is to be noted that in every instance there is a marked loss in growth but not a complete cessation. This slight growth can be ascribed to the part of cartilage not destroyed or to a certain potential power possessed by the cartilage cells that are not injured. It is also to be noted that a portion of the plate was not injured in some of the experiments, as the incision did not pass directly through the line of separation. Thus a certain amount of growth was possible from the portion that remained.

TABLE VIII.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
29	30-73	9 days	0.15 cm.	0.1 cm.	0.25 cm.
30	144-85	28 "	0.4 cm.	0.45 cm.	0.85 cm.
31	128-78	51 "	0.5 cm.	0.35 cm.	0.85 cm.
32	123-76	62 "	0.8 cm.	0.35 cm.	1.15 cm.
33	15-50	79 "	1.8 cm.	——	——

3. Cross Incision Through the Metaphyseal Region, Raising and Reimplanting of the Distal Piece.

Method. A cross incision is made through the metaphyseal region.

The tissues about the distal segment are severed along with the joint capsule. The fragment is then raised from its bed and reimplanted, after which it is held in place by sutures into the surrounding tissues. This experiment is practically a reimplantation of the entire epiphysis and metaphysis.

EXPERIMENT 34 13 DAYS. DOG 30-38 OLD SERIES.

Operation. Reimplanted the distal one-third of the bone.

Gross Findings. There is good healing although union is not especially firm. There is no increase in the length of the operated or normal bone.

Microscopical Findings. The articular cartilage appears normal The marrow of the epiphysis is necrotic. The nuclei of the trabeculae of the epiphysis are pale. The epiphyseal cartilage plate is broader than normal but its cellular elements appear practically normal. There is some degeneration of the osteoid tissue of the metaphysis. The remainder of the bone appears normal.

EXPERIMENT 35. 44 DAYS. DOG 130-79.

Operation. Cut across just proximal to the metaphysis of the metatarsal IV of the right hind foot, removed and reimplanted the distal fragment. The bone measures 3.2 cm.

Gross Findings. The joint capsule is thickened and the articular cartilage is not so smooth as normal. On longitudinal section the epiphyseal cartilage plate is found to be broader than normal. The epiphyseal marrow has a mottled appearance. The line of union is quite firm. The measurements are: Metatarsal IV, left, 3.8 cm.; difference, 0.45 cm.; right, 3.35 cm. Thus there is a loss of 0.45 cm. The growth since the operation is 3.35—3.2=0.15 cm., while the normal growth is 0.6 cm. The Roentgenogram shows a considerable irregularity in the epiphyseal cartilage plate. The line of union is faintly visible. As compared with its fellows of the opposite side there is a definite shortening of the operated bone. The entire epiphyseal end of the bone is deformed.

EXPERIMENT 36. 44 DAYS. DOG 41-39 OLD SERIES.

Operation. The record of this experiment was lost, so that it is possible to give only the final results. They are: Loss of growth, 0.5 cm. Growth of the operated bone is zero, while the normal growth is 0.5 cm.

SUMMARY ON CUTTING ACROSS PROXIMAL TO THE EPIPHYSEAL REGION, RAISING AND REIMPLANTING THE DISTAL FRAGMENT.

In practically every instance there is a complete loss of growth following such an operation. Degenerative changes take place at first in the marrow and trabeculae but later there is a regeneration of these parts. The epiphyseal cartilage plate undergoes a gradual degeneration and is practically devoid of further function.

TABLE IX.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
34	30-38	13 days	0	0	0
35	130-79	44 "	0.45 cm.	0.15 cm.	0.6 cm.
36	41-39	44 "	0.5 cm.	0	0.5 cm.

GROUP IV. LONGITUDINAL INCISION AND REMOVAL OF ONE-HALF OF SECTION.

1. Longitudinal Incision Through the Epiphysis up to Metaphysis and Removal of One-Half.

Method. After exposing the bone a longitudinal incision is made through the articular cartilage and epiphysis up to the line of cleavage between the epiphysis and metaphysis. One of the halves of the epiphysis is then removed leaving the other half intact. The wound is closed in the usual manner.

EXPERIMENT 37. 22 DAYS. DOG 146-86.

Operation. Removed the medial half of the epiphysis of the metatarsal III of the right hind foot. The bone measures 3 cm. The animal died at the end of 22 days.

Gross Findings. A capsule has formed over the end of the bone. There is only a slight amount of fluid in the joint. The articular cartilage is smooth. There is a definite outgrowth of osseous tissue about the stump of metaphysis. The epiphyseal cartilage plate in the immediate vicinity of the severed end appears ossified. The Roentgenogram shows a slight shortening of the bone. Fig. 1. There is a deviation of the cut end to the medial side. There is a certain tendency for a filling up of the gap caused by the excision of the medial half. The measurements are: Metatarsal III, left, 3.7 cm.; difference, 0.4 cm.; right, 3.3 cm. Thus there is a loss of 0.4 cm. in length. The normal bone has increased 0.7 cm., while the operated has increased but 0.3 cm.

EXPERIMENT 38. 51 DAYS. DOG 127-78.

Operation. Removed the medial half of the metacarpal III of the left fore foot. The bone measures 3.0 cm. The animal died at the end of 51 days.

Gross Findings. There is good healing. The articular surface of the operated bone is deflected toward the side of the removed piece. There is a definite tendency to cover the raw surfaces. The epiphyseal cartilage plate appears normal as does the remainder of the bone. The Roentgenogram shows the definite shortening as compared with its fellow of the opposite foot. The bone is deflected toward the medial side. There is a certain evening up of the bone in the region of the epiphyseal cartilage plate. (See Fig. 4.) The measurements are: Metacarpal III, left, (op.) 3.35 cm.; difference, 0.55 cm.; right, 3.9 cm. Thus there is a loss of 0.55 cm. in the operated bone. The growth of the bone is 0.35 cm. as compared with 0.9 in the normal. (See Fig. 4).

FIG. 4.—Experiment 38. 51 days. Dog 127-78. Removal of the medial one-half of the epiphysis. Right in photograph, B, third bone from right, 3, is the operated bone. Compare 3B with 3A in order to see the disturbance in growth, as normally they are the same length. Also notice the deviation toward the medial side and compare with the neighboring bone, 4, in which the bending is toward the lateral side, corresponding to the side that was removed.

Experiment 42. 51 days. Dog 126-78. Removal of the lateral one-half of the epiphysis and metaphysis. Right in photograph, second bone from the right, 4, is the operated bone. The lateral one-half of the epiphysis has been removed. Notice the deviation of the bone toward the side from which the piece was removed. Compare with 4, of A, in order to get the amount of shortening, as they are normally of equal length.

EXPERIMENT 39. 81 DAYS. DOG 18-53.

Operation. Cut away the lateral half of the epiphysis of the metacarpal III of the right fore foot. The bone measures 2.6 cm. The animal was killed by gas at the end of 81 days.

Gross Findings. There is good healing. There is considerable irregularity about the articular end of the bone, with a defect in the articular cartilage on the lateral side. On longitudinal section the epipyseal cartilage plate is found to be almost absent. There is a mass of new tissue extending into the epiphysis which appears to be young osteoid tissue. The remainder of the epiphysis appears normal. The Roentgenogram shows the marked shortening, also the irregular form of the bone and the absence of the epiphyseal cartilage plate. The measurements are: Metacarpal III, left, 4.65 cm.; difference, 1.8 cm.; right, 2.85 cm. Thus there is a loss of 1.8 cm. since the operation. The operated bone has increased .25 cm., while the normal has increased 2.05 cm.

SUMMARY OF REMOVAL OF ONE-HALF OF THE EPIPHYSIS.

In each instance there was a definite decrease in the length of the bone which was proportionately greater with the elapse of time.

The bone in every instance showed very minimal amount of growth after such an operation. This fact must be taken into consideration when a piece of an epiphysis is used for transplantation for clinical purposes as advised by some investigators.

TABLE X.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
37	146-86	22 days	0.4 cm.	0.3 cm.	0.7 cm.
38	127-78	51 "	0.55 cm.	0.35 cm.	0.9 cm.
39	18-53	81 "	1.8 cm.	0.25 cm.	2.05 cm.

2. Excision of One Lateral Half of the Bone Including the Epiphysis and Metaphysis.

Method. A longitudinal incision is made, extending from the articular surface down through the metaphysis and one of the halves of the bone is removed.

EXPERIMENT 40. 13 DAYS. DOG 110-72.

Operation. Removed the medial half of the metacarpal III of the right fore foot. The measurement of the bone is 2.7 cm. The animal died at the end of 13 days.

Gross Findings. There is good healing. The bone appears to be re-

suming a normal appearance and is encapsulated in fibrous tissue. The measurements are: Metacarpal III, left, 3.05 cm.; difference, 0.15 cm.; right, 2.9 cm. (op.). Thus there is 0.2 cm. growth of the operated bone and 0.35 cm. of the normal.

EXPERIMENT 41. 48 DAYS. DOG 116-74.

Operation. Removed the medial half of the metacarpal IV of the left fore-foot beyond the epiphyseal region. The bone measures 2.7 cm. The animal died on the 48th day after the operation.

Gross Findings. There is good healing. The joint is covered over and the articular cartilage that remains is smooth. The end of the bone is deflected toward the medial side. The exposed piece of epiphysis and diaphysis is covered by new cortex. The epiphyseal cartilage plate appears slightly narrower than normal and there is a loss of vascularity of the neighboring bone. The measurements are: Metacarpal IV, left (op.), 2.9 cm.; difference, 0.4 cm.; right, 3.3 cm. Thus there is a loss of 0.4 cm. in length. The operated bone has increased 2.9—2.7=0.2 cm. in length, while the normal growth has been 3.3 cm.—2.7 cm.=0.6 cm.

EXPERIMENT 42. 51 DAYS. DOG 126-78.

Operation. Removed the lateral half of the epiphysis and metaphysis of the metacarpal IV of the left fore foot. The entire length is 3.0 cm. The animal died at the end of 51 days.

Gross Findings. The bone is deflected toward the lateral side. There is a definite tendency to encapsulate the end of the bone, also to form a new wall of cortex on the lateral side. The remainder of the bone appears normal. The Roentgenogram shows the shortening and deflecting of the bone. The epiphyseal cartilage plate is irregular. Notice the tendency to reëstablish the original form of the bone. (See Fig. 4.) The measurements are: Metacarpal III, left, (op.) 3.4 cm.; difference, 0.4 cm.; right, 3.8 cm. Thus there is a loss of 0.4 cm. The growth of the operated bone has been 3.4—3.0=0.4 cm., while the normal measures 3.8—3.0=0.8 cm. (See Fig. 4.)

SUMMARY ON EXCISION OF ONE LATERAL HALF OF THE EPIPHYSIS AND METAPHYSIS.

There is a definite hindrance in growth after the removal of such a portion of bone. The disturbance is about the same as if only a half of the epiphysis up to the line of cleavage of the epiphyseal cartilage plate is removed.

TABLE XI.

EXP. NO.	DOG NO.	DURATION	LOSS OF GROWTH	GROWTH OF OPERATED	GROWTH OF NORMAL
40	110-72	73 days	0.15 cm.	0.2 cm.	0.35 cm.
41	116-76	48 "	0.4 cm.	0.2 cm.	0.6 cm.
42	126-78	51 "	0.4 cm.	0.4 cm.	0.8 cm.

3. Removal of the Longitudinal Half of the Entire Bone.

Method. The entire bone is split longitudinally and one-half is removed. The wound is then closed in the usual manner.

Experiment 43. 3 Days. Dog 150-87.

Operation. Split the metacarpal IV of the left fore foot and removed the lateral one-half. The bone measures 3.6 cm. The animal died in 3 days.

Gross Findings. The duration of the experiment is too short to allow any deductions and merely shows the primary healing.

(To be continued.)

The following notice, which is being sent out from Washington, should be heeded by medical men as well as by those in other branches of the service:

Treasury Department, Washington.
December 4, 1918.

To the Soldiers and Sailors of America:

Approximately four million officers and men of the Army and Navy are now insured with the United States Government for a grand total of almost thirty-seven billion dollars

You owe it to yourself and to your family to hold on to Uncle Sam's insurance. It is the strongest, safest, and cheapest life insurance ever written.

For your protection Uncle Sam has established the greatest life insurance company in the world—a company as mighty, as generous, and as democratic as the United States Government itself. Just as Uncle Sam protected you and your loved ones during the war, so he stands ready to continue this protection through the days of readjustment and peace.

The privilege of continuing your Government insurance is a valuable right given to you as part of the compensation for your heroic and triumphant services. If you permit the insurance to lapse, you lose that right, and you will never be able to regain it. But if you keep up your present insurance —by the regular payment of premiums—you wll be able to change it into a standard Government policy *without medical examination.* Meantime you can keep up your present insurance at substantially the same low rate. The Government will write ordinary life insurance, twenty-payment life, endowment maturing at age 62, and other usual forms of insurance. This will be Government insurance—at Government rates.

The United States Government—through the Bureau of War Risk Insurance of the Treasury Department—will safeguard you and your loved ones with the spirit and purpose of a Republic grateful to its gallant defenders. To avail yourself of this protection, you must keep up your present insurance. Carry back with you to civil life, as an aid and asset, the continued insurance protection of the United States Government.

Hold on to Uncle Sam's insurance.

W. G. MCADOO, *Secretary.*

A STUDY OF BURIED BONE.

BY JOHN FRANCIS COWAN AND LEONARD W. ELY, SAN FRANCISCO.

(From the Laboratory of Surgical Pathology, Leland Stanford Junior University.)

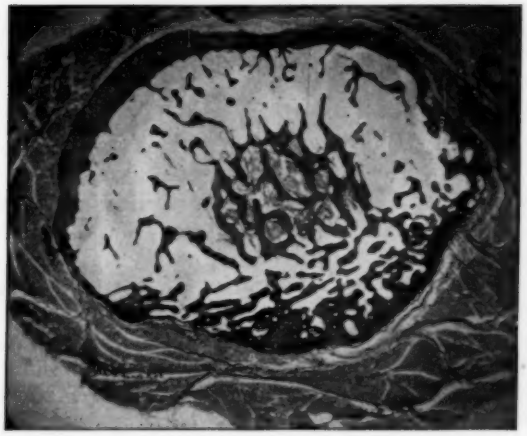
THE material for this study was gained in a series of knee joint resections in the dog, the results of which have been published recently.[1] In ten of these cases the patella was imbedded: in one a fragment of the femoral condyle; in one, a fragment from the tibial head. The bone was buried in the animal from which it had been removed a few minutes previously. An incision was made deep in the muscles on the lateral aspect of the thigh, and the bone was inserted. The wound was sutured in two layers, and was dressed with collodion and gauze. The operated limb was put in a plaster spica. The wounds healed by first intention. The animals died or were killed from 14 to 432 days after operation. At the autopsy the bone was removed with the surrounding tissue, in which it was firmly imbedded. The material was fixed in alcohol or Orth's fluid, dehydrated in alcohol, decalcified in 5% nitric acid, run up in the alcohols, and imbedded in colloidin. Sections cut with a microtome, were stained with hematoxylin and eosin, and with the van Gieson stain. All operations were done under ether anesthesia.

DOG 8. 432 Days. The dog was killed by ether anesthesia. Bone removed, with surrounding muscle tissue.

Histology. The patella is almost completely encapsulated by a thin layer of fibrous tissue, though in places over the cartilage the muscle tissue is immediately contiguous, and the fibrous capsule is wanting. The cartilage cells stain fairly well, and the cartilage itself seems to be in a good state of preservation, except at its surface, where it is irregular and notched. In these irregular notches fibrous tissue is seen. The bone buttress under the cartilage is almost gone, and the trabeculae in this region are scant and small.

The bony "cortex" on the other side of the patella is being replaced by fibrous tissue. The marrow is fatty, except near the center, where there is an area in which the marrow is fibrous. No rarefying osteitis is seen. In this central area many of the trabeculae stain deeply with hematoxylin at their borders. A few bone cells stain, but the bone is dead. The trabeculae also are thicker than in the rest of the patella, but their interior portion does not stain so well, and has empty lacunae. No connection can be seen between this fibrous marrow and the fibrous capsule.

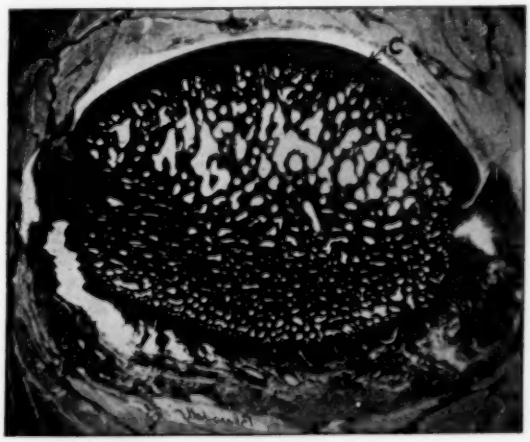
Encapsulation. Erosion of cartilage at its surface, but persistence of most of the cartilage in good shape. Much dead bone still present, but absorption of many of the trabeculae. Fatty and fibrous marrow. The bone buttress under the cartilage is almost gone.



Dog. 8B.

Dog 12. 14 Days. The dog died of hemorrhagic septicemia.

The Patella. A well-marked fibrous capsule is present. The surface of the cartilage is fairly smooth for most of its extent, and is not ad-



Dog 12B.

herent to the capsule, except for a short distance at its ends. Its cells do not stain. It is evidently dead. The bony cortex (on the part of the patella not covered by cartilage) is continuous with the fibrous capsule and stains irregularly in streaks and patches with hematoxylin. The fibres of the capsule seem to run into the bone. The trabeculae themselves are abundant and thick, but all the bone in the specimen is dead and stains very poorly. The marrow spaces of the denser part of the bone are engorged with blood.

Encapsulation. Adherence of small part of cartilage to capsule, the rest of its surface smooth. No bony absorption. Death of bone and cartilage.

Dog 13. 88 Days. The dog died of pneumonia.

The patella, of approximately the same size as when buried, is encapsulated by fibrous tissue. The cartilage persists, but is irregular in thickness and in outline. Some of its cells stain well. Many of them retain their capsules. Some have lost them. The cartilage is being replaced by fibrous tissue at its surface, and immediately beneath it is a thin layer of lymphoid marrow. The bony buttress under the cartilage has disappeared almost entirely.

The layer of "cortical" bone on the rest of the patella has been changed to fibrous tissue, so that the line of division between the buried specimen and the capsule cannot be exactly made out.

The trabeculae immediately under the cartilage are small and scant. In the rest of the bone near the circumference they are somewhat diminished in number and size. The marked change in them, however, is in their structure. They seem to be fading away. The ground substance has been mostly absorbed. The trabeculae have a hyaline and granular appearance.

In the marrow bordering these trabeculae are layers of cells, polymorphonuclears, endothelial leucocytes and lymphocytes, and an occasional myelocyte. The rest of the marrow is mostly fatty.

In the center of the specimen the trabeculae present the same appearance of absorption, but are not edged by the cellular layers. Here the marrow consists of dense fibrous tissue. In other words, where the marrow is fatty, the trabeculae are bordered by a thin layer of lymphoid marrow; where it is fibrous, they are not.

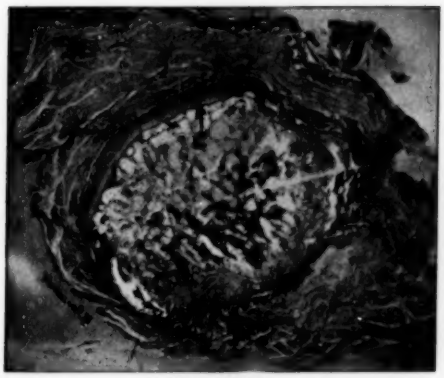
It is to be noted that in spite of the virtual disappearance of the bone, no evidence is present of rarefying osteitis—no osteoclasts in Howship's lacunae.

The marrow throughout the specimen, except, of course, in the fibrous areas, is engorged. The "blood sinuses" are full of blood. This is the usual appearance of the marrow in animals dying of infectious disease. In other words, the marrow in this specimen of buried bone removed from an animal which died of an infectious disease was still reacting as marrow ordinarily does.

Encapsulation. The cartilage is eroded, but its cells stain fairly well. The buttress has disappeared. The trabeculae are undergoing absorption, but not by osteoclasts. The marrow is fatty and fibrous, and is engorged.

Dog 14. 117 Days. The cause of death was not ascertained.

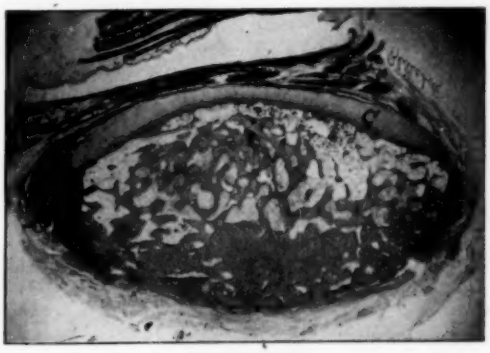
The patella has a complete fibrous capsule. The cartilage in some slides remains, except at one end, though irregular in outline. In other slides it exists only as islands. Its cells stain fairly well. Underneath the cartilage the bone trabeculae are rather thin and sparse, and the buttress of bone is almost gone. In sections where the cartilage exists as mere islands, the fibrous tissue can be seen entering the bone among the islands. The marrow underneath the cartilage is for



Dog 14B.

the most part fatty, the rest fibrous. The cortical bone on the side opposite the cartilage is being replaced by fibrous tissue. The trabeculae stain very poorly, and irregularly, and are dead. They look as if they were breaking down. The marrow itself is engorged with blood, indicating that the animal died of an infectious disease.

Encapsulation. Disappearance of much of the cartilage, and of the buttress. Bone trabeculae dead and disappearing, but not by the action of "osteoclasts." Fibrous and fatty marrow.



Dog 15B.

Dog 15. 240 Days. The dog was killed with ether.

The patella, apparently somewhat diminished in size, is encapsulated by fibrous tissue. The cartilage looks fairly healthy. Under the high power its cells stain fairly well, but their capsules are indistinct. Its surface is irregular and notched, and has been encroached upon by fibrous tissue. It is irregular, also, in thickness. It is much thinner near the middle than at the side. Under the cartilage is a buttress of osteoid tissue, much thinner than normal. Directly under this buttress the marrow is fatty and the trabeculae are very scant.

In the centre of the specimen is an area of fibrous marrow which extends down to the dense layer of cortical bone on the side opposite the cartilage, and this fibrous tissue can be traced along through the dense bone to the periphery, where it communicates with the fibrous tissue of the capsule. The rest of the marrow is fatty.

The bone trabeculae in the central area and in the portion of the bone opposite the cartilage are quite dense and have lost their cells. They shade into the fibrous marrow. One gets the impression that the bone is being replaced by fibrous tissue, but the bone itself stains well.

The cells of the cortical bone are also missing; a very few are present. The fibrous tissue at the periphery is encroaching upon the bone. Here and there blood vessels can be seen pushing their way through the dense bone. At the place where the original tendon ran into the bone, its fibres persist, and its cells change into cartilage cells as it runs into bone.

A few osteoclasts can be found by diligent search, but rarely in Howship's lacunae.

Encapsulation. Much of the bone persists, though it is dead. The cartilage is irregular, but still alive. Its buttress consists of osteoid tissue. The marrow is fatty, fibrous and lymphoid.

Dog 16. 97 Days. Cause of death: Pulmonary embolus, old, organized pneumonia, organized cardiac thrombus.

The patella is surrounded by muscle and fibrous tissue. The cartilage is thin and very irregular, and at its surface it is being replaced by fibrous tissue. Some of the cells of the portion remaining are in fair condition, but many are dead. Most of the bony cortex of the rest of the patella also has been replaced by fibrous tissue. The trabeculae are thin and sparse, and have lost their cells. They are dead. The basement substance of many of the trabeculae is breaking up, apparently in the process of absorption, and stains irregularly and poorly. No evidence of rarefying osteitis is present.

The marrow is mostly fatty; some areas of lymphoid marrow are present.

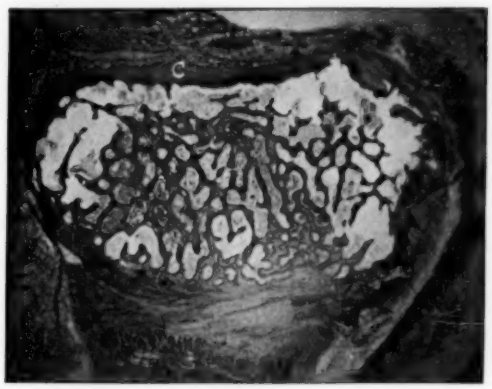
Encapsulation. Partial disappearance of cartilage and of bone, and the death of the remainder. No rarefying osteitis. Fatty and lymphoid marrow.

Dog 17. 347 Days. The dog was killed with chloroform.

The patella is well encapsulated. The cartilaginous portion is intimately connected with the capsule, and its superficial portion has been replaced by fibrous tissue. One end of of the cartilage strip has been replaced by fibrous tissue. The remaining cartilage itself is in fairly good condition. Its cells stain well. The surface of the cartilage is irregular. Most of the bony cortex of the rest of the periphery has been replaced by fibrous tissue.

The bone trabeculae are somewhat scantier than normal. A few of their cells are present, especially near the periphery of the specimen, but most of the lacunae are empty. The bone is dead. The marrow is largely fibrous and in this fibrous tissue are many blood vessels. Es-

specially near the periphery of a portion of the specimen the marrow is fatty. Here and there an osteoclast can be seen.



Dog 17B.

Encapsulation. The cartilage has been largely replaced by fibrous tissue. Part of the bone has been replaced by fibrous tissue. Most of the bone is dead. The marrow is mostly fibrous.

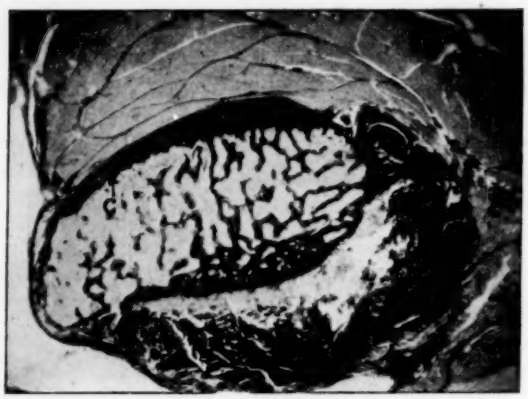
Dog 18. 317 Days. The dog was killed.

The patella (smaller than when buried) is encapsulated by fibrous tissue. About one-half the cartilage is absent, and the marrow is separated from the encapsulating tissue only by a thin layer of osteoid tissue. The rest of the cartilage persists, and is eroded at its surface. Its cells stain well, but have lost their capsules. The layer of osteoid tissue, thinning out, can be traced along under a portion of the cartilage to form a sort of buttress, finally ceasing. No bony buttress is present anywhere. Only a few very small trabeculae are seen below the cartilage. Near the periphery of the bone the trabeculae are small and scant, and the marrow is fatty. The trabeculae show in several places near the center well marked rarefying osteitis (osteoclasts in Howship's lacunae). Most of the bone is dead. The marrow in the small central portion consists of fibrous tissue. This fibrous tissue can be traced in one place almost to the periphery, on the side opposite the cartilage. The layer of cortical bone on the side opposite the cartilage is very thin, and evidently is being replaced by fibrous tissue. In places the bone tissue has been entirely replaced by fibrous tissue. One small patch of lymphoid marrow is seen beneath the persisting strip of cartilage.

Encapsulation. Partial disappearance of cartilage and disappearance of bony buttress. Partial disappearance of bone trabeculae. Almost all the remaining trabeculae have lost their cells. Dead bone. The marrow is fibrous and fatty, with a little lymphoid.

Dog 19. 40 Days. The cause of death is unknown.

The patella is partly encapsulated by fibrous tissue. The cartilage is faced by muscle tissue, whose fibres actually seem to run into it at



Dog 19B.

an angle, the line of junction not being sharp. The bony cortex of the patella is continuous with the surrounding fibrous tissue in most places. In one area there is a typical capsule. A complete true capsule is absent, in other words.

The structure of the cartilage is fairly well preserved. The cells stain fairly well, and the basement substance appears normal. Apparently a small piece has disappeared from one end. The subjacent buttress is present under about half the cartilage; wanting or diminished under the other half. In the region of the former the marrow is fibrous; in the latter, lymphoid and fatty. Throughout about two-thirds of the patella the marrow is delicately fibrous; throughout one-third it is fatty and slightly lymphoid.

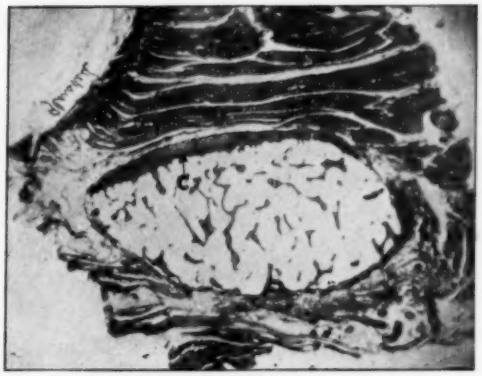
The trabeculae stain poorly and irregularly. Their cells are absent. Fibrous tissue appears to be replacing some of them, and they are lessened in thickness and in number. In the region of the fatty marrow, where the trabeculae are sparse, a very little typical rarefying osteitis is seen—osteoclasts.

The "blood sinuses" are greatly engorged. The trabeculae appear to be breaking up and to be undergoing absorption, but for the most part not lacunar absorption.

Encapsulation not complete. Bone trabeculae disappearing; cartilage also. Fibrous and fatty marrow. Absorption of much of the bone. Death of the rest. Engorgement of blood sinuses. Buttress partially gone.

Dog 20. 304 Days. The dog was killed by chloroform anesthesia.

The patella is surrounded by a capsule of fibrous tissue, very delicate in some places. The bony cortex is very thin, and in places is absent, being replaced by fibrous tissue. The bone trabeculae stain well, but in places the bone cells are absent, especially in the interior of the trabeculae; in others they are present and stain well, especially at their border—"border apposition." The trabeculae are sparse. The buttress beneath the cartilage is absent, and the normal piling up of trabeculae; on the other side of the bone, the thick "cortex" is also



Dog 20.

absent. The marrow is fatty, with a very few small patches of lymphoid marrow. No fibrous marrow is seen.

The cartilage is thin, and is eroded and irregular at its surface. Fibrous tissue is replacing its superficial portion. Its cells stain deeply with hematoxylin and are in a good state of preservation. Some have lost their capsules. A few capsules are without cells. Blood vessels are abundant in the marrow.

Encapsulation. Replacement of most of the cortex by fibrous tissue. Partial absorption of bone trabeculae; some of the remaining trabeculae are dead, but most of them living. Cartilage thin and eroded, but still living. Subjacent buttress absent. Marrow mostly fatty, with a little lymphoid.

Dog 21. 255 Days. The dog was killed by chloroform.

Piece of head of tibia. At autopsy this seemed to have diminished in size.

The surface of the cartilage is slightly irregular and its superficial portion has been replaced by fibrous tissue, which separates it from the surrounding muscle. The fibrous capsule is complete about the rest of the buried fragment, and has not extended into the marrow, although as there was no bone cortex, it had free access to the interior. The marrow is fatty and lymphoid. The trabeculae are rather scanty, and the bone buttress is absent under part of the cartilage. The bone lacunae of the trabeculae are empty.

Encapsulation. Degeneration of the surface of the cartilage. Partial absorption of bony buttress and trabeculae. Death of bone. No fibrous change of the marrow.

Dog 22. 47 Days. The dog was killed with chloroform during pneumonia.

The bone fragment, a piece of the femoral condyle, has a fibrous capsule, and with this capsule the cartilaginous portion is intimately connected. In places the surface of the cartilage is fibrillated. The cartilage itself seems fairly normal, but the buttress beneath it is absent. The trabeculae are sparse, and stain irregularly. They seem to be undergoing absorption. Their cells are absent for the most part.

The marrow is lymphoid. No fibrous marrow is present, and the fibrous tissue from the capsule has no tendency to push into the bone. The marrow stains well, and contains blood vessels and sinuses.

Encapsulation. Beginning bone absorption. Some of the cells of the trabeculae still alive, most of them absent. Cartilage in good condition, except at its surface. The subjacent buttress has disappeared.

CONCLUSION.

A patella, or the fragment of another bone, imbedded fresh in the muscle of the animal from which it was removed, has a tendency to disappear, but does not disappear, at least for a long time. In none of our cases had it disappeared completely. Its structure becomes less dense.

The bone tissue itself may be replaced by fibrous tissue, especially at or near the circumference, or it may be absorbed.. Absorption is the rule in the interior. Occasionally typical rarefying osteitis by osteoclasts is seen. More frequently the process seems to be one of simple absorption—"halisteresis." The method of absorption is often difficult to determine, for about many of the trabeculae there are no giant cells, no leucocytic infiltration, and no increased vascularity of the marrow.

Many of the cells disappear early from the bone. Others stain well after the expiration of a long time. Death of bone is the rule.

A patella, with a complete investment of bone and cartilage, does not resist absorption better than a bone fragment whose marrow is exposed to the surrounding tissue.

A blood supply is established in the marrow of the buried bone.

The marrow has a tendency to become fatty and fibrous, though patches of lymphoid may persist. It is engorged in animals who have died with an acute infectious disease, as is the marrow of normal bone in such circumstances. In other words, it is functionating as marrow.

Cartilage becomes eroded at its surface, and is replaced by fibrous tissue. Sometimes it disappears completely in areas. Its cells often stain well after a long time. Sometimes they die after a shorter time. The buttress underneath the cartilage almost always disappears early.

Judging from appearances, the buried bone becomes smaller in size.

Roughly, the changes in bone and cartilage are the same as those seen in arthritis of Type I—atrophic, or proliferative arthritis.

REFERENCE.

[1] Bone and Joint Studies. I. Leonard W. Ely and John Francis Cowan, Stanford University, Cal. Published by the University, 1916.

NOTE: The illustrations are all low-power photo-micrographs. "C" refers to the cartilage.

PSEUDOCOXALGIA FOLLOWING TRAUMATIC DISLOCATION OF THE HIP IN A BOY AGED FOUR YEARS.*

BY R. C. ELMSLIE, M.S., F.R.C.S., LONDON, ENGLAND,

Orthopædic Surgeon, St. Bartholomew's Hospital.

THE x-ray photographs presented are of the left hip of a boy who came to my out-patient department at St. Bartholomew's Hospital on February 2nd, 1914. There had been a fall on January 25th and upon examining the boy I found that his left hip was dislocated. As dislocation of the hip by violence at so early an age is so rare as to be unrecorded in surgical literature, I had an x-ray photograph taken in the dislocated position and then reduced the dislocation upon the x-ray table. A second plate was then taken to show the reduction. The x-rays show that at this time the head of the femur was perfectly normal. As the boy lived some distance out of London, the hip was fixed in plaster-of-Paris for safety, for a fortnight. The plaster was then removed and the hip left to recover its mobility.

FIG. 1.—Posterior view of left hip, Feb. 2, 1914, before reduction of dislocation.

* A paper read before the British Orthopædic Association.

On April 12th, 1915, the patient was brought back to the hospital because since January of that year he had been limping and complaining of pain in the hip after walking. Until January there had been no trouble, and there had never been any pain at night. The hip was again x-rayed, a roughening of the head of the femur found which was thought to be due to tuberculous disease, and the hip was fixed in plaster-of-Paris. I did not see the boy at this time, nor have I a copy of the x-ray.

The hip was kept in plaster-of-Paris until September 4th, 1915, when I next saw the patient. On examining the x-ray I at once recognized it as showing the characteristic changes of pseudocoxalgia, as described first by Calvé. An x-ray taken at this date I am able to show. It shows the irregularity of the epiphysis of the head of the femur, with thinning where the upper margin of the acetabulum presses upon it, and also the broadening of the neck of the bone which is to some extent overlapped at the edges by the epiphysis.

FIG. 2.—Anterior view, left hip, Sept. 5, 1915, showing characteristic changes of pseudocoxalgia.

All treatment was stopped and the boy allowed to walk freely upon the limb.

I have kept the case in view up to the present time. There is now

evident thickening of the neck of the femur, which can be felt. Movements of the hip are free except full abduction. The last x-ray, taken in February, 1918, four years after the original accident, shows great thickening of the neck of the femur, and a very broad epiphysis, which, however, now has a smooth upper surface.

FIG. 3.—Anterior view of left hip, Feb. 2, 1918, showing the thickened neck and wide, thin epiphysis characteristic of the late stage of pseudocoxalgia.

These x-ray photographs are instructive for two reasons. In the first place, following up this case over a period of four years has shown that the bony surface of the head of the femur eventually becomes quite smooth. This, I think, shows that the roughening apparent in the early photos of these cases of pseudocoxalgia is a roughening of the bony nucleus and not of the cartilage which covers it. This might also be inferred from the fact that in these cases the movements of the joint remain free throughout, except, perhaps, for short periods in which a transient synovitis of the joint occurs.

In the second place the occurrence of pseudocoxalgia in this case as a direct sequel of a traumatic dislocation, suggests a possible anatomical cause for the condition. It is well known that pseudocoxalgia occurs exclusively in children aged from four to seven, and that there is usually some preceding accident. It is also noticeable that changes which are exactly similar occur in the bony muscles of the head of the femur in children with congenital dislocation of the femur after reduction of the dislocation. The changes, being chiefly in the bony nucleus, at least in the early stages, suggest that there may be some nutritional disturbance of this nucleus. I suggest that the condition is due to an interference with the nutrition of this nucleus, due to an injury to its vascular supply, which at this period must be conveyed in the *ligamentum teres*. An injury to this ligament may quite well occur in a traumatic dislocation of the hip and also in the reduction of a congenital dislocation. At a later stage, when the neck of the femur is less cartilaginous, it is likely that a considerable vascular supply may reach the epiphysis of the head of the bone through the retinacula. Possibly when the supply through the *ligamentum teres* is sufficient, that through the retinacula increases, and this increased vascularity around the neck of the femur may help in causing the thickening of the femoral neck.

For comparison I present some other x-rays of cases of pseudocoxalgia from my collection. In one of them the condition arose after a definite arthritis which occurred during an attack of chorea. In another a late stage of the condition in an older child is shown. The neck is very thick and the head broad and thin, but smooth, as in the case now reported.

Discussion.

Mr. Harry Platt gave an epidiascope demonstration of radiograms of cases of pseudo-coxalgia. He added: These are two plates showing flattening of the head of the femur, where the condition does not fall into the class of pseudo-coxalgia. I think they are cases of tuberculous foci in the neck of the femur.

The first of my cases is that of a child of four years, and it is a very advanced and typical case of bilateral pseudo-coxalgia. You can easily see the thinned-out head and fragmented nucleus. On the other side, the flattening at the head is not so marked. Major Elmslie anticipated what I am going to say. From the observation of a dozen cases which I have followed for four years, what has impressed me has been that the accepted pathology, looking upon these cases as purely traumatic cases, seems to be wrong, though it is impossible to deny that this condition may develop after a definite severe injury such as that which Major Elmslie demonstrated, or an injury resulting from reduction of a congenital hip dislocation. The question which I have worked at was as to whether flattening of the head of the femur is the prime lesion in these cases or whether the primary lesion is in the neck of the femur. And, if that is so, is it possible to get a flattening of the head of the femur in such con-

ditions as tuberculosis of the neck of the bone? There are two plates in my series of definite cases of tuberculous foci in the neck of the femur, both showing a flattened head, although the head of the femur is not fragmented and does not show hyper-calcification. In the bilateral cases of pseudo-coxalgia I have seen there is no history of trauma. In one case the patient had been treated for two years on a Thomas hip splint for so-called right tuberculous hip, and when I saw him he had both right and left hips affected, the left showing more advanced pseudo-coxalgia than the right. There was no weight-bearing on the right side but flattening had developed in spite of the rest. In this patient's case there is no history of injury. I feel that this appearance of flattening of the head of the femur is not pathognomonic of any one disease, but may be produced by nutritional changes, the result of an injury or of some pyogenic or tuberculous infection of the neck of the femur. I should particularly like to hear what Capt. Kidner has got to say on this subject as I know it is a subject which he also has investigated along the same lines.

THE PRESIDENT: These are most interesting cases which have been illustrated by Major Elmslie and Captain Platt, and I hope we shall have an interesting discussion on them. There is one point I would remind you of, and that is that there are changes in the bony nucleus of the femur in these cases similar to those which occur in Schlatter's disease and in Kohler's disease also. There is an apparent likeness in these cases; whether there is a real likeness I do not know. It is a point which it will be interesting to have brought out, and I hope some speakers may enlighten us on it. I ask Capt. Kidner to make some remarks.

CAPTAIN KIDNER, U. S. A.: The work of Legg, which far preceded the work of Perthes on this condition of pseudo-coxalgia, seems to have given the clearest possible explanation of the causation. Legg felt, in 1910 or 1911, that the condition was one of traumatism of vessels in the neck of the femur with secondary loss of substance in the sub-epiphyseal line and a partial loss of the deposition of lime salts, with the irregular thickening which is so common in all these cases. That explanation seemed, at the time, satisfactory. But then we began to discover cases in which there was no history of traumatism and it occurred to many men that there might be an infection which was localized in the neck of the femur through a thrombosis which interfered with the nutrition of the upper end of the neck, with the epiphyseal line secondarily involved with the resultant loss of calcium deposit. I had a very interesting case of that sort in 1913. The skiagram showed a cavity, such as that which Mr. Platt has now shown, and which I believed to have been an osteomyelitic abscess. I drained it and got from it a low-grade staphylococcus which was culturable. Removal of the focus was followed by a condition which presented the typical x-ray picture of pseudo-coxalgia, followed by recovery without any subsequent flattening of the head. The cases which Captain Platt and Major Elmslie have shown are particularly interesting from various standpoints. In the first case Major Elmslie showed he gives us the pictures and attributes the appearance of the diseased part sometime afterwards to the traumatism. It seems to me probable that the course of events has been the reverse. I think the skiagram taken at the time of the dislocation and that taken shortly afterwards both clearly show early stages of pseudo-coxalgia, not in the changes of the head but in the sub-epiphyseal line. But it is difficult to tell from the reproductions. Still, I imagine there would tend to appear in the original x-ray plates a marked scalloping of the sub-epiphyseal line and a moderate cavity formation in the epiphysis.

In regard to Captain Platt's cases, I very much wonder what are his grounds for saying the condition was tubercular. I have wondered whether he operated or simply based his opinion on the course of the disease. It seems to me that his cases, which he regards as tubercular, were clear cases of staphylococcic or other low-grade infection with abscess formation in the neck and with secondary changes in the head due to interference with circulation.

MR. LAMING EVANS: I would ask Major Elmslie one question and that is whether he has come across cases where the acetabulum has been involved in these cases. I have a skiagram of a case which I take to be one of pseudo-

coxalgia in which the acetabulum was definitely affected. If so, the theory of Major Elmslie is, it seems to me, difficult to maintain.

MAJOR ELMSLIE: I do not think there is much for me to reply to. In answer to Mr. Laming Evans' question, I have seen cases in which there were changes in the acetabulum and I think I am right in saying that Calvé, in his original paper which, I believe, was published in 1909, mentioned that, in some cases, particularly in rather advanced cases with a lot of alteration in the head, there may be a little roughening and irregularity of the upper part of the acetabulum. I do not think that affects any theory as to the origin of the condition because I do not think that roughening of the acetabulum means anything more than adaptive changes in the acetabulum. Perhaps I did not explain myself as clearly as I meant to in putting forward what Mr. Laming Evans regards as the vascular theory. I should rather call it the nutritional theory, and I would prefer to say that I think the condition of flattening and mushrooming of the head of the femur, which we call, in this country, pseudo-coxalgia is due to some change in nutrition in the epiphysis of the head of the femur. I agree with the President that the changes are similar to the other changes one sees in the epiphysis or tubercle of the tibia in Schlatter's disease and in the heel in a condition which, I believe, was first described by Haglund. I suggest that these changes are nutritional, that they are due to various causes, but what I wish to suggest is that, in certain of the cases, such as those originally described by Calvé, in which there is no other lesion but apparently a healthy child without any abscess or infection of the neck of the femur and without any acute symptoms, this condition of the head of the femur occurs and that in those cases the lesion may be due to nutritional changes which are started by an alteration in the vascular supply through injury to the ligamentum teres. I do not regard all these cases of change in the head of the bone as of uniform origin.

CAPTAIN PLATT (in reply): In answer to Captain Kidner's remarks concerning the diagnosis of tuberculosis, I must admit it was rather a "label" than otherwise, though the three cases give a definite von Pirquet reaction and they are all young children. The other cases of definite pseudo-coxalgia in my series have given negative reaction. Another interesting point is that every case I have seen has got well marked signs of rickets. With regard to the original description of Calvé, in 1910, the point he laid stress on was the enlargement of the head of the femur, so much so that it could easily be felt. In one of my cases the head of the femur is greatly enlarged so that it forms a marked prominence in the anterior aspect of the thigh. I have not found this sign in any of the others. It is possible that these cases, which are still under treatment, with definite foci in the neck of the femur, may be either pneumococcal, staphylococcal or some other form of low-grade infection. But they all show extreme restriction of joint movement at the present time and a positive von Pirquet reaction and one is looking upon them, for purposes of practical treatment, as tuberculous. I think there will have to be some line drawn between the cases which definitely progress to the thin, flattened-out head with fragmentation and—a point which has not been emphasized enough—the marked hyper-calcification in the nucleus, and the other type of case, namely, that where, with a focus in the neck, there is simply flattening of the head, but the neck shows atrophic changes such as you find in a typical tuberculous joint.

THE TREATMENT OF CHRONIC OSTEOMYELITIS DUE TO GUN SHOT INJURIES.

BY C. F. EIKENBARY, CAPTAIN, M.R.C., U.S.A.

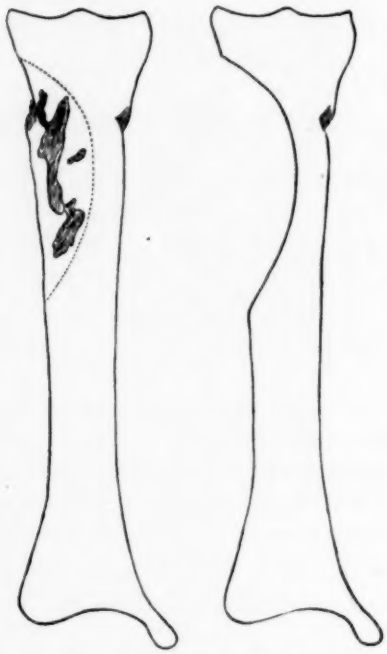
CHRONIC osteomyelitis, due to gun shot injuries, differs only in minor ways from chronic osteomyelitis in civil life. After all, we are dealing with exactly the same pathology, excepting that in gun shot injuries we may have to deal with some foreign substances, and not infrequently, with an ununited fracture as well. But the surgical procedure that is best in military surgery, is also the best procedure in civil surgery.

Almost without exception cases of chronic osteomyelitis, civil or military, have sinuses leading down to necrosed bone. Occasionally a sinus may heal, leaving a sequestrum, usually small, surrounded by a small quantity of pus, which pus, having very slight virulence, may permit of the condition remaining dormant for an indefinite time. It is the writer's opinion, however, that sooner or later, practically all these cases have exacerbations, and therefore should be cleaned out without delay.

It has seemed to the writer that in civil surgery these cases were too frequently treated by the curette—the bone or sinus "scraped" as the layman is wont to say—with the result that the sinus either re fused to heal, or else healed only temporarily, the tract soon breaking down and discharging pieces of necrosed bone. And thus the patient goes on with his daily or tri-weekly dressings over a period of months or years. Cases of discharging sinuses persisting for many years, and finally being cured by an amputation are all too frequent.

From June 12, 1917, until November 20, 1917, the writer had an opportunity of seeing and operating a great many cases of chronic osteomyelitis (gun shot cases), in Bellahouston Hospital, Glasgow, Scotland. In all these cases sinuses had persisted for a long time, and in all of them sequestra could be demonstrated by the x-ray. In many instances there were metallic substances as well. Frequently the metallic substances were entirely surrounded by perfectly healthy bone and therefore demanded no interference.

Operation. If possible, an Esmarch and tourniquet were always applied. The operative procedure was a rather radical one. A long incision was made over the necrosed area, as indicated by the x-ray. If the sinus opening was near the sequestrum, and at a point favorable



GUNSHOT INJURY TO TIBIA.

Compound fracture. Healing with very little deformity. Osteomyelitis, with sequestra. Dotted line shows the line of bone incision. Appearance after operation.

for the avoidance of blood vessels and important nerve structures, then it was included in the incision. If not, it was disregarded. The bone having been exposed over a large area, the sinus leading down to the sequestrum was searched for. When found, and this was usually quite easy, the bone was chiseled away at this point, and the sequestrum removed. The length of the necrotic area was then estimated, and in this we were guided not only by the probe but by the x-ray as well. Having estimated the length of the necrotic area, both distally and proximally, the bone was chiseled away for a distance of approximately an inch above and below the diseased region, the chisel at either end of the bone incision being driven in in a very *slanting manner*. If feasible, the sides were also cut away either by a chisel or a bone biting forceps. No *sharp angles* or *spicules* were ever left. In the end we had a large depression, the floor of which was the healthy bone below what had been the necrotic area. If any wall were left, it also was made perfectly smooth and very slanting. The curette was

not used at all, except occasionally to remove pieces of bone already cut loose by the chisel.

A couple of sutures were placed at either end of the incision, and the wound firmly packed with plain sterile gauze strips. No antiseptic gauze was ever used. At the end of twenty-four hours the original packing was removed and the wound lightly packed with the same type of sterile gauze. Within a few days the packing merely extended through the soft parts.

The whole aim of the operation is:

1. To get rid of all necrotic bone.
2. To avoid leaving any cavity at all.
3. To avoid spicules, rough areas, etc.

Results. Almost without exception, these cases healed within four weeks. Many were healed within three weeks, and in one instance healing was complete in two weeks.

The procedure may possibly be better understood from the more or less schematic drawing which accompanies this paper.

Book Reviews

Over Beenvorming. Dr. Murk Jansen. E. J. Brill, Leiden, 1918.

The author, who is well known to many orthopædic surgeons by his excellent book on Achondroplasia, has made another remarkable contribution to the orthopædic science by this book, which is dedicated to Sir Robert Jones. After a thorough discussion of the mechanical laws of internal bone architecture the book deals with the changes of the internal architecture of bones in many of the most common deformities, such as severe flat foot, kyphosis, scoliosis, ankylosed knee, coxa vara, spondylitis deformans, etc.; also certain deformities of joints of animals. The illustrations are excellent and they alone would make the book very valuable even for those who cannot read the Dutch language. We hope that the author will, in time, issue a translation into English, French, or German, to give the volume a wider publicity, which it deserves.—*C. H. Bucholz.*

Orthopædic Surgery. Edited by Edwin W. Ryerson, M.D. The Practical Medicine Series, 1918. Chicago: The Year Book Publishers

The synopsis, which is really a review of the literature in orthopædic surgery, with the valuable experience of the author combined, makes the information contained in this volume very valuable to the orthopædic student. It is particularly interesting for the orthopædic war surgery, to which considerable space is given, with descriptions and illustrations of the splints, which is valuable to one who has not had the opportunity of using these new forms of apparatus.

The book should be of interest also to the general practitioner, as it is concise, and will help in the diagnosis and in the advice which should be given to patients suffering from orthopædic difficulties.—*L. T. Swaim.*

Current Orthopaedic Literature

Numerals at head of each abstract are for use in connection with the official "Classification of Orthopædic Literature," published in the JOURNAL for January, 1917, reprints of which are obtainable from the JOURNAL office.

III. ORTHOPÆDIC OPERATIVE, POST OPERATIVE, AND ADJUVANT TECHNIC.

III, 7.

WAR SURGERY OF THE WRIST. Combier and Murard. *Revue de Chir.*, Vol. 37, Nos. 1 and 2.

This study is based upon the author's personal observation of 27 wounds of the wrist. In order to classify various types of wounds of the wrist joint. distinction is made as follows:

1. Wounds of the wrist without bone lesions.
2. Osseous lesions limited to one bone of the carpus.
3. Osseous lesions involving several bones.
4. Lesions of the carpal joints.
5. Lesions of the radio carpal joints.
6. Isolated fractures of the radial epiphysis without lesion of the wrist.

1. Wounds of the wrists without bone lesions are found in tangential wounds, often from small projectiles, which penetrate with little force and are arrested within the capsule. The ideal treatment consists in suture of the synovia after lavage. The open tendon sheaths are carefully restored and the tendons re-united. The authors often observed hematoma in the tendon sheath. In this case they prefer to incise the hematoma so as to avoid infection.

2. In joint wounds limited to one bone of the carpus it is possible to make the surgical interference very conservative, by removing the debris and curetting the surface and, after lavage with ether, closing the capsule. This conservative procedure was carried out in one case where partial dissection of the semi-lunar bone was made, with splendid results.

The conservative method is of greatest importance when dealing with the second row of carpal bones, especially the trapezium and unciform bone. In one case the author was able to preserve the trapezium and with it the stability of the thumb.

More often, however, fracture of one of the carpal bones will lead to extraction of the bone involved, and for this reason it is interesting to know the orthopædic value of isolated resection of the carpal bones.

Regarding the proximal row of bones, extraction of the scaphoid was done in a number of cases.

After resection in one case slight deviation of the hand outward was noticed, but otherwise the functional result was good, notwithstanding the fact that the scaphoid is of considerable indirect importance for the action of the thumb. The removal of the semilunar bone has likewise given good functional results, although some observers dispute its advisability and even prefer total resection of the wrist. This latter point, however, might apply more to old dislocations in which there are secondary modifications of the

carpus. The triquetrum, being only a superstructure of the wrist, might also be removed without great functional disturbance, and likewise the pisiform bone, as this is merely a sesamoid bone of the flexor carpi ulnaris.

Isolated resections of the distal row of carpal bones are more frequent than those of the proximal row. There are often accompanying fractures of the metacarpal bones. The trapezium was removed in one case, and, in spite of its importance for the stability of the thumb movement, the latter was found to be preserved, although limited and slightly painful.

In one case the trapezoid was resected with very good functional result. The removal of the os magnum, although of more serious consequence than that of the others, has given good results in one case reported. The condition two months after operation was as follows:

Extension was incomplete except that of the thumb. Flexion was also incomplete but rapidly improving. First and second interossei not acting. Movement of the wrist: Extension and flexion almost normal, as are lateral motions and pro and supination.

Of isolated removal of the unciform bone one case is reported. The removal of this bone involves the motility of the fourth and fifth fingers. Based upon this experience it is safe to conclude that isolated removal of carpal bones is a very promising procedure, attended by good results, especially in cases of removal of the scaphoid and semilunar bone, which are more frequent than any other. There is, however, every reason to believe the removal of any other bone of the carpus will yield equally satisfactory results.

3. Multiple Osseous Lesions. Ollier advised in multiple osseous lesion to perform a simple resection of the bone fragment by opening the tract and removing the detached bone splinter. This resection of the fragment, however, seems to the author an insufficient procedure today, when the walls of the wound appear to be so frequently infected and when the mechanical disinfection must be thorough and methodical. The author prefers in these cases, the arthrotomy, which is a more systematic procedure and much surer of results. Where circumstances permit, an immediate closure with drainage follows arthrotomy and careful dissection of the bone. Nevertheless, in two cases extraction of the splinters was performed with only moderate result.

Partial resection of the wrist was carried out in the proximal row of carpals by simultaneous resection of the scaphoid and semilunar. In one case the end result was, six months after operation, only moderate. There was only little power in the wrist and flexion-extension movement was incomplete. The radiographic study of these cases shows deviation of the hand radially. For this and other reasons the authors believe it preferable to combine the removal of the scaphoid with that of the semilunar and triquetrum, that is, practically the entire proximal row of carpals.

There was no partial resection performed on the distal row, but it is undoubtedly a very difficult procedure and should rather be substituted by total resection of the carpus.

The total resection of the carpus was performed for multiple fracture of the bones of the wrist. From the orthopædic viewpoint the results of carpectomy are quite satisfactory.

Regarding technic, the wrist should be approached by dorsal incision following outer border of the extensor indicis. In this resection the trapezoid is very important and should be saved, first, because it is very difficult to reach, and secondly, because it is very important for the motion of the first metacarpal bone. Likewise the pisiform bone may be left without inconvenience, and it is also preferable to leave the apophysis of the unciform bone for the reason that it is a point attachment for the anterior annular ligament

of the wrist. In regard to mobilization after operation, it is pointed out by the authors that this should be carried out in two phases. The mobilization of the fingers constitutes the first phase and should be carried out as quickly as possible, the fixation apparatus applied at operation leaving the finger free for this purpose. Later, mobilization of the wrist should be undertaken, which must be carried out for a length of time, and a palmar splint reaching beyond the basal phalanx should be worn between treatments.

Results. Results are evidently inferior to those of resection for closed fractures. This is due to many other intervening factors which determine ultimately function of the wrist, such as wounds of the soft parts, especially tendon sheaths, and of the nerve and blood supply.

In spite of these factors, results are, while moderate, still vastly superior to those of amputation and disarticulation. In three cases in which total resection was performed, results were as follows:

In one case, ankylosis and slight mobilization, giving the arm good functional use, after one year.

In the second case, movable wrist, with good function after 14 months.

In the third case, complete ankylosis, after 14 months, with good functional use of the wrist.

Ankylosis seems to be the most frequent outcome of total resection. It is entirely compatible with the use of the arm in a good many cases. Partial ankylosis is especially favorable. Ollier points out that in extension and flexion an amplitude of 40 or 45 degrees is sufficient and that one can play the piano with motility at 25 degrees. The most important point is lateral stability.

4. Carpo-Metacarpal Lesions. Metacarpal lesions very frequently accompany wounds of the wrist joint. In one group of cases there are injuries of the base of the metacarpal co-existing with partial fractures of the distal row. It is of the greatest importance to preserve the base of the metacarpal for the sake of the architecture of the hand as well as of the attachments of the interossei muscles. Results of partial resection of the metacarpal bases are unsatisfactory for several reasons: First, on account of the mechanical disturbance of the palmar arch formed by the metatarsal, then also on account of the interference with the insertion of the interossei. The outcome of these resections is much inferior to that of carpectomy, and the movement of the fingers is almost *nil*. If one is obliged to resect the metacarpal bone, the corresponding finger should also be disarticulated. If resection of several metacarpals is necessary it is often better to perform disarticulation of the wrist.

5. Carpo Ante-brachial Lesions. In total fractures of the carpus and the epiphysis of the forearm the resection of the wrist combined with that of the forearm epiphyses, while giving less satisfactory results than carpectomy, is surely more promising than resection of the carpo-metacarpus.

The greatest disadvantage is the shortening of the skeleton and with it the relaxation of the extensor tendons. The latter point is taken care of by shortening of the tendons. In partial fractures of the carpus and of the epiphyses of the forearm, an economic resection might be done.

6. Fracture of the Epiphysis of the Forearm without Lesion of the Carpus. The procedure in these cases consisted in resection of the forearm fragment without touching the wrist. The epiphysis might be taken care of by separate incision on both sides of the forearm. A case of fracture of the epiphysis of the radius was operated by the authors, with the result that two and one-half months later the patient had complete range of motion in flexion and lateral abduction, though extension was still somewhat limited.

In infected wounds of the wrist the surgical procedures depend very much upon the extent and nature of the infections. Non-virulent, or limited, infections are observed in wounds on the third and fourth day following insufficient primary intervention. These cases do not require treatment essentially different from the one already mentioned.

In cases of suppurative arthritis, however, the conditions are vastly different. This infection is not at all limited to joints, but involves also the synovial sheaths, the tendons and soft structures, and, possibly, bones of the forearm. Among four cases of the latter group amputation was performed in one. In three cases resection of the carpus was performed on the third twenty-third and twenty-eighth day after injury. Comparatively good results were obtained in the latter three cases, and healing took place, in one case, after three months, and in another case, after six months.—*Arthur Steindler, Iowa City.*

III, 7.

SURGERY AT FRONT HOSPITAL. Pool, Lee, Dineen. *Surg., Gyn. and Obst* Sept., 1918.

In a 22 page article the authors cover their winter's experiences with Colonel Depage at La Panne. This abstract covers only the orthopædic portions of their paper.

Fractures divide into compound fractures caused by projectiles; compound fractures caused by accident, and simple fractures.

Compound fractures caused by projectiles necessitate the same surgical technique for the wound as if there were no fracture. If the projectile passes to the bone, the fracture should be exposed freely, fragments detached from periosteum removed, viable pieces left *in situ*. Free irrigation with salt solution removes small dirt particles. If the bone has been fractured through transmitted shock and is not exposed to the wound, do not expose. Wounds sterilized with Carrel-Dakin solution, and delayed primary or secondary closure made. Osteomyelitis is favored by a closed infected wound. It is inadvisable to use plates or wire in an infected wound, as osteomyelitis may result.

Apparatus for compound fractures. Perfect reduction, immobilization, accessibility to the wound and comfort are striven for. Frequent X-ray examinations are necessary Sinclair aims to employ sufficient traction to elongate the limb, replacing most of the fragments, correcting abnormal position of nerves, blood vessels and lymphatics, and favoring repair. For upper arm and shoulder fractures, suspending with hammock from Sinclair rod, abducted, straight elbow position, traction on forearm, allows of accessibility and gives fair immobilization. Thomas and Blake splints are also uesd; cock-up splints for wrist, hand and fingers. For the upper third of the femur no thoroughly satisfactory method seems to have been devised Thomas, Hodgen and Sinclair splints are used. Weight and pulley with overhead counter traction is freely used for fractures lower down. Compound fractures caused by accident are treated similarly.

Simple fractures are treated as in civil practice.

Wounds of joints. (1) Good surgical technique; (2) Careful radioscopy and radiography; (3) during operation every possible means of exact foreign body localization; (4) most painstaking soft tissue dissection so that surgeon does not open spaces that are not opened by the projectile; (5) the joint must not be opened without satisfactory demonstration of a wound of entry. Incisions made directly over the foreign body. (6) Complete excision

of all soiled, lacerated tissues and removal of all foreign bodies; (7) irrigation of joint with saline and flushing with ether; (8) complete primary suture is vitally important in joint surgery; (9) early active joint movement prohibits formation of fibrous bands, aids in the expulsion of blood clots. Immediate mobilization may be delayed 5 or 6 days if there has been considerable loss of muscle tissue overlaying an extensive bony lesion.

In wounds without injury of bone or with little injury of soft parts or bone, the incision of approach to the joint must be determined by the situation of the skin wound of entrance and exit or by the position of the foreign body itself. After careful removal of soiled injured tissues, foreign bodies, irrigation of wound, it is immediately closed in layers. Active mobilization of the joint is begun the following day, 3 to 4 times daily, at least once at night. This is very painful at first, less so later. Walking is started the day following operation, if possible, in lower extremity cases, dusting, etc., for upper extremity cases.

A new method of treating acute purulent arthritis has lately been employed. The knee or elbow is usually opened laterally, use no drainage material, employ no irrigations, change hot moist dressings every two hours for 48 to 72 hours, active movement of the joint every 2 hours, waken the patient 2–3 times a night. It is maintained that the joint will drain itself if active movements are kept up. The patients are quite uncomfortable during the early weeks.

Wounds of the hand and foot are frequent; the watchwords are conservation of tissue, primary suture and early passive motion.—*Leo C. Donnelly, Detroit.*

III, 7 and XV, 1.

Surgical Consideration of Peripheral Nerve Injuries. Byron Stookey. *Surg., Gyn. and Obstet.* Oct., 1918.

In war injuries, nerve suture can be done only in a sterile field, hence nerve suturing must be done in secondary operations. It is impossible to determine without waiting for nerve degeneration to manifest itself, to state whether a nerve will regenerate without operative interference. 40 to 60 per cent. recover without interference; interference might have shortened convalescence. So long as there are progressive signs of nerve regeneration, as formication, shrinkage of areas of anaesthesia, return of deep sensibility, return of muscle tone and sensibility, operation should be postponed. Formication is elicited by gentle pressure on the nerve trunk, producing a peculiar creeping sensation referred to the peripheral distribution of the nerve. When signs of nerve regeneration cease to progress or do not appear, then operation is indicated. Three to four months should be waited for their appearance.

Nerve operations are operations of choice, being done only where ample facilities are present and after thorough study. Under general anaesthesia a dry field without the use of a tourniquet is prepared by free hemostasis, bleeding from nerve ends controlled by prolonged digital pressure, bits of torn muscle held in apposition, etc. Trace the nerve through scar tissue by following from the healthy part from above down, and below up. Cut only partially through scar nerve, using the scar to help hold ends together and to prevent axial rotation. End to end apposition is desired. Small, smooth, round, half curved needles with either fine silk or plain catgut are used. The suture includes as little nerve as possible.

There are three main types of operation: neurolysis or nerve liberation; suture, partial or complete; and nerve grafting. Nerve liberation is suc-

cessful only when the nerve has been completely freed and there is no scar tissue present in the nerve. If there is only a very small amount of scar tissue present the injections under pressure of sterile salt solution may open up paths for the neuraxes; if there is considerable scar, resect and suture.

Direct nerve suture should be done only when the nerve ends can be brought in apposition without tension. Gentle traction may be used; altering the position of the limb aids. Suturing under tension fails because it means an increase of scar tissue.

In excising scar make consecutive thin sections until normal nerve appears. then only can plan of nerve bridging be considered. In partial nerve suture one removes the scar tissue without injuring the normal nerve funiculi. The radial below the elbow, musculo-cutaneous of the arm or leg, can be used as grafts. The nerve should be loosely surrounded with a fat pedicle or buried in muscle or placed between muscle bellies. Tendon transplantation may obviate the necessity of nerve suture. When nerve injuries are associated with aneurism the prognosis for successful interference is poor.—*Leo C. Donnelly, Detroit.*

V, 2, a.

V. TUBERCULOSIS.

DIAGNOSIS AND TREATMENT OF TUBERCULOUS ARTHRITIS OF THE HIP JOINT. H. W. Meyerding. *Minn. Med.*, Aug., 1918.

He gives a very good table of differential diagnosis

1. Traumatic arthritis or periarticular injury is differentiated by local tenderness, ecchymosis, history, negative x-ray, while impaction fractures later cause limp, and shortening due to loosening of the impaction, positive X-ray.

2. Chronic hypertrophic arthritis appears in older people and shows characteristic lipping without rarefaction. The limitation of motion is usually in abduction and rotation and there is little or no muscle spasm, shortening etc.

3. Infectious arthritis is usually multiple, acute, accompanied by high fever and leucocytosis. Removal of local infection leads to rapid recovery. Aspiration and bacterial examination aid in differential diagnosis.

4. Perthes' disease, osteochondritis deformans juvenilis, may be differentiated by characteristic epiphyseal changes.

5. Infantile paralysis is easily differentiated in the paralytic stage, in the acute stage there may be local pain and tenderness for a short time.

6. Arthritis of the knee allows motion of the hip without pain, when the knee is immobilized and whole leg carefully manipulated.

7. Pott's disease of the lumbar spine has as its earliest symptom muscle rigidity. Careful manipulation of the hip with negative X-ray rule out hip.

8. Congenital dislocation lacks muscle spasm, rigidity, atrophy, etc., and is positively diagnosed by the gait, palpation, and X-ray.

As to treatment, sunshine, fresh air, simple substantial food, are preferable to medicine. Local treatment dependent on the stage of the disease and the circumstances. He prefers Jones abduction frame which allows of fixation and extension, relieves pain and spasm and corrects deformity.

The patient remains on the frame until acute symptoms subside, general condition improves, deformity is corrected and there is a redisposition of lime salts. During the subacute stage, if no drainage exists, the patient may be up in a cast of Lorenz type, the well leg raised with high heel.

Patients in subacute or chronic stage have deformity corrected by brisement forcé or Gant osteotomy.—*Leo C. Donnelly, Detroit.*